Model 2000 Multimeter

Repair Manual

Contains Servicing Information

KEITHLEY

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Model 2000 Multimeter
Repair Manual

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Manual Print History

The print history shown below lists the printing dates of all Revisions and Addenda created for this manual. The Revision Level letter increases alphabetically as the manual undergoes subsequent updates. Addenda, which are released between Revisions, contain important change information that the user should incorporate immediately into the manual. Addenda are numbered sequentially. When a new Revision is created, all Addenda associated with the previous Revision of the manual are incorporated into the new Revision of the manual. Each new Revision includes a revised copy of this print history page.

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Safety Precautions

The following safety precautions should be observed before using this product and any associated instrumentation. Although some instruments and accessories would normally be used with non-hazardous voltages, there are situations where hazardous conditions may be present.

This product is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read the operating information carefully before using the product.

The types of product users are:

Responsible body is the individual or group responsible for the use and maintenance of equipment, and for ensuring that operators are adequately trained.

Operators use the product for its intended function. They must be trained in electrical safety procedures and proper use of the instrument. They must be protected from electric shock and contact with hazardous live circuits.

Maintenance personnel perform routine procedures on the product to keep it operating, for example, setting the line voltage or replacing consumable materials. Maintenance procedures are described in the manual. The procedures explicitly state if the operator may perform them. Otherwise, they should be performed only by service personnel.

Service personnel are trained to work on live circuits, and perform safe installations and repairs of products. Only properly trained service personnel may perform installation and service procedures.

Exercise extreme caution when a shock hazard is present. Lethal voltage may be present on cable connector jacks or test fixtures. The American National Standards Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30V RMS, 42.4V peak, or 60VDC are present. **A good safety practice is to expect that hazardous voltage is present in any unknown circuit before measuring.**

Users of this product must be protected from electric shock at all times. The responsible body must ensure that users are prevented access and/or insulated from every connection point. In some cases, connections must be exposed to potential human contact. Product users in these circumstances must be trained to protect themselves from the risk of electric shock. If the circuit is capable of operating at or above 1000 volts, no conductive part of the circuit may be exposed.

As described in the International Electrotechnical Commission (IEC) Standard IEC 664, digital multimeter measuring circuits (e.g., Keithley Models 175A, 199, 2000, 2001, 2002, and 2010) measuring circuits are Installation Category II. All other instruments' signal terminals are Installation Category I and must not be connected to mains.

Do not connect switching cards directly to unlimited power circuits. They are intended to be used with impedance limited sources. NEVER connect switching cards directly to AC mains. When connecting sources to switching cards, install protective devices to limit fault current and voltage to the card.

Before operating an instrument, make sure the line cord is connected to a properly grounded power receptacle. Inspect the connecting cables, test leads, and jumpers for possible wear, cracks, or breaks before each use.

For maximum safety, do not touch the product, test cables, or any other instruments while power is applied to the circuit under test. ALWAYS remove power from the entire test system and discharge any capacitors before: connecting or disconnecting cables or jumpers, installing or removing switching cards, or making internal changes, such as installing or removing jumpers.

Do not touch any object that could provide a current path to the common side of the circuit under test or power line (earth) ground. Always make measurements with dry hands while standing on a dry, insulated surface capable of withstanding the voltage being measured.

Do not exceed the maximum signal levels of the instruments and accessories, as defined in the specifications and operating information, and as shown on the instrument or test fixture panels, or switching card.

When fuses are used in a product, replace with same type and rating for continued protection against fire hazard.

Chassis connections must only be used as shield connections for measuring circuits, NOT as safety earth ground connections.

If you are using a test fixture, keep the lid closed while power is applied to the device under test. Safe operation requires the use of a lid interlock.

If a ⏚ screw is present, connect it to safety earth ground using the wire recommended in the user documentation.

The ⚠ symbol on an instrument indicates that the user should refer to the operating instructions located in the manual.

The ⚠ symbol on an instrument shows that it can source or measure 1000 volts or more, including the combined effect of normal and common mode voltages. Use standard safety precautions to avoid personal contact with these voltages.

The WARNING heading in a manual explains dangers that might result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The CAUTION heading in a manual explains hazards that could damage the instrument. Such damage may invalidate the warranty.

Instrumentation and accessories shall not be connected to humans.

Before performing any maintenance, disconnect the line cord and all test cables.

To maintain protection from electric shock and fire, replacement components in mains circuits, including the power transformer, test leads, and input jacks, must be purchased from Keithley Instruments. Standard fuses, with applicable national safety approvals, may be used if the rating and type are the same. Other components that are not safety related may be purchased from other suppliers as long as they are equivalent to the original component. (Note that selected parts should be purchased only through Keithley Instruments to maintain accuracy and functionality of the product.) If you are unsure about the applicability of a replacement component, call a Keithley Instruments office for information.

To clean the instrument, use a damp cloth or mild, water based cleaner. Clean the exterior of the instrument only. Do not apply cleaner directly to the instrument or allow liquids to enter or spill on the instrument.

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1 Routine Maintenance

Introduction

The information in this section deals with routine type maintenance that can be performed by the operator. This information is arranged as follows:

- Setting line voltage and replacing fuse — Explains how to select the alternate power line voltage setting, and how to replace a blown power line fuse.
- Amps fuse replacement — Explains how to replace a blown current fuse.

Setting line voltage and replacing fuse

A rear panel fuse located next to the AC receptacle (in the power module) protects the power line input of the instrument. If the line voltage setting needs to be changed or the line fuse needs to be replaced, perform the following steps.

WARNING ***Disconnect the line cord at the rear panel and remove all test leads connected to the instrument (front and rear) before replacing the line fuse or changing the line voltage setting.***

1. Place the tip of a flat-blade screwdriver into the power module by the fuse holder assembly (see Figure 1-1). Gently push in and to the left. Release pressure on the assembly and its internal spring will push it out of the power module.
2. Remove the fuse and replace it with the type listed in Table 1-1.

CAUTION ***For continued protection against fire or instrument damage, only replace fuse with the type and rating listed. If the instrument repeatedly blows fuses, locate and correct the cause of the trouble before replacing the fuse.***

3. If configuring the instrument for a different line voltage, remove the line voltage selector from the assembly and rotate it to the proper position. When the selector is installed into the fuse holder assembly, the correct line voltage appears inverted in the window.
4. Install the fuse holder assembly into the power module by pushing it in until it locks in place.

Figure 1-2
Power module

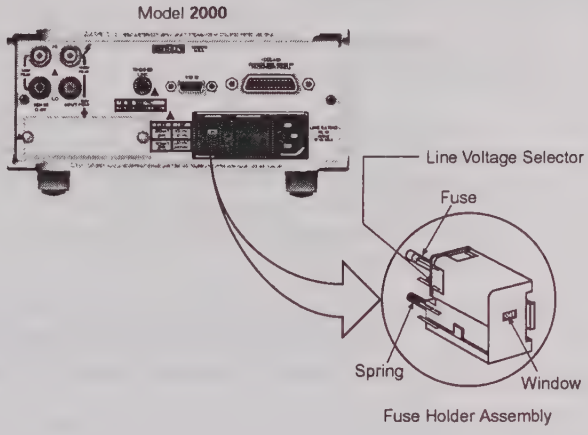


Table 1-1
Fuse rating

Line voltage	Fuse rating	Keithley part no.
100/120V	0.25A slow-blow 5×20mm	FU-96-4
220/240V	0.125A slow-blow 5×20mm	FU-91

AMPS fuse replacement

WARNING ***Make sure the instrument is disconnected from the power line and other equipment before replacing the AMPS fuse.***

1. Turn off the power and disconnect the power line and test leads.
2. From the front panel, gently push in the AMPS jack with your thumb and rotate the fuse carrier one-quarter turn counter-clockwise. Release pressure on the jack and its internal spring will push the fuse carrier out of the socket.
3. Remove the fuse and replace it with the same type 3A, 250V, fast blow: Keithley part number FU-99-1.

CAUTION ***Do not use a fuse with a higher current rating than specified or instrument damage may occur. If the instrument repeatedly blows fuses, locate and correct the cause of the trouble before replacing the fuse.***

4. Install the new fuse by reversing the procedure.

2
Troubleshooting

Introduction

WARNING ***The information in this section is intended for qualified service personnel. Some of these procedures may expose you to hazardous voltages. Do not perform these hazardous procedures unless you are qualified to do so.***

This section of the manual will assist you in troubleshooting the Model 2000. Included are self-tests, test procedures, troubleshooting tables, and circuit descriptions. It is left to the discretion of the repair technician to select the appropriate tests and documentation needed to troubleshoot the instrument. This section is arranged as follows:

- Repair considerations — Covers some considerations that should be noted before making any repairs to the Model 2000.
- Power-on test — Describes the tests that are performed on memory elements each time the instrument is turned on.
- Front panel tests — Provides the procedures to test the functionality of the front panel keys and the display.
- Principles of operation — Provides support documentation for the various troubleshooting tests and procedures. Included is some basic circuit theory for the display board, power supply, digital circuitry and analog circuitry.
- Display board checks — Provides display board checks that can be made if front panel tests fail.
- Power supply checks — Provides power supply checks that can be made if the integrity of the power supply is questionable.
- Digital circuitry checks — Provides some basic checks for the digital circuitry.
- Analog signal switching states — Provides tables to check switching states of various relays, FETs, analog switches and the A/D multiplexer for the basic measurement functions and ranges.
- Built-in test overview — Summarizes the built-in tests, which can be used to test and exercise the various digital and analog circuits.
- Built-in test documentation — Provides a detailed analysis of each built-in test.

Repair considerations

Before making any repairs to the Model 2000, be sure to read the following considerations.

CAUTION ***The PC-boards are built using surface mount techniques and require specialized equipment and skills for repair. If you are not equipped and/or qualified, it is strongly recommended that you send the unit back to the factory for repairs or limit repairs to the PC-board replacement level. Without proper equipment and training, you could damage a PC-board beyond repair.***

1. Repairs will require various degrees of disassembly. However, it is recommended that the Front Panel Tests and Built-In-Test be performed prior to any disassembly. The disassembly instructions for the Model 2000 are contained in Section 3 of this manual.
2. Do not make repairs to surface mount PC-boards unless equipped and qualified to do so (see previous CAUTION).
3. When working inside the unit and replacing parts, be sure to adhere to the handling precautions and cleaning procedures explained in Section 3.
4. Many CMOS devices are installed in the Model 2000. These static-sensitive devices require special handling as explained in Section 3.
5. Anytime a circuit board is removed or a component is replaced, the Model 2000 must be recalibrated.

Power-on test

During the power-on sequence, the Model 2000 will perform a checksum test on its EPROM (U156 and U157) and test its RAM (U151 and U152). If one of these tests fails the instrument will lock up.

Front panel tests

There are two front panel tests: one to test the functionality of the front panel keys and one to test the display. In the event of a test failure, refer to "Display Board Checks" for details on troubleshooting the display board.

KEY test

The KEY test allows you to check the functionality of each front panel key. Perform the following steps to run the KEY test:

1. Press SHIFT and then TEST to access the self-test options.
2. Use the ▲ or ▼ key to display "TEST: KEY".
3. Press ENTER to start the test. When a key is pressed, the label name for that key is displayed to indicate that it is functioning properly. When the key is released, the message "NO KEY PRESS" is displayed.
4. Pressing EXIT tests the EXIT key. However, the second consecutive press of EXIT aborts the test and returns the instrument to normal operation.

DISP test

The display test allows you to verify that each pixel and annunciator in the vacuum fluorescent display is working properly. Perform the following steps to run the display test:

1. Press SHIFT and then TEST to access the self-test options.
2. Use the ▲ or ▼ key to display "TEST: DISP".
3. Press ENTER to start the test. There are four parts to the display test. Each time ENTER is pressed, the next part of the test sequence is selected. The four parts of the test sequence are as follows:
   A. All annunciators are displayed.
   B. The pixels of each digit are sequentially displayed.
   C. The 12 digits (and annunciators) are sequentially displayed.
   D. The annunciators located at either end of the display are sequentially displayed.
4. When finished, abort the display test by pressing EXIT. The instrument returns to normal operation.

Principles of operation

The following information is provided to support the troubleshooting tests and procedures covered in this section of the manual. Refer to the following block diagrams:

Block Diagrams:

Figure 2-1 — Power supply block diagram
Figure 2-2 — Digital circuitry block diagram
Figure 2-3 — Analog circuitry block diagram

Display board

Microcontroller

U401 is the display board microcontroller that controls the display and interprets key data. The microcontroller uses three internal, peripheral I/O ports for the various control and read functions.

Display data is serially transmitted to the microcontroller from the digital section via the TXB line to the microcontroller RDI terminal. In a similar manner, key data is serially sent back to the digital section through the RXB line via TDO. The 4MHz clock for the microcontroller is generated by crystal Y401.

Display

DS401 is the display module, which can display up to 12 alpha-numeric characters and the various annunciators.

The display uses a common multiplexing scheme with each character refreshed in sequence. U402 and U403 are the drivers for the display characters and annunciators. Note that data for the drivers are serially transmitted from the microcontroller (MOSI and PC1).

Filament voltage for the display is derived from the power supply transformer (F1 and F2). The display drivers require +37VDC and +5VDC, which are supplied by U144 (+5VD) and U101 (+37V).

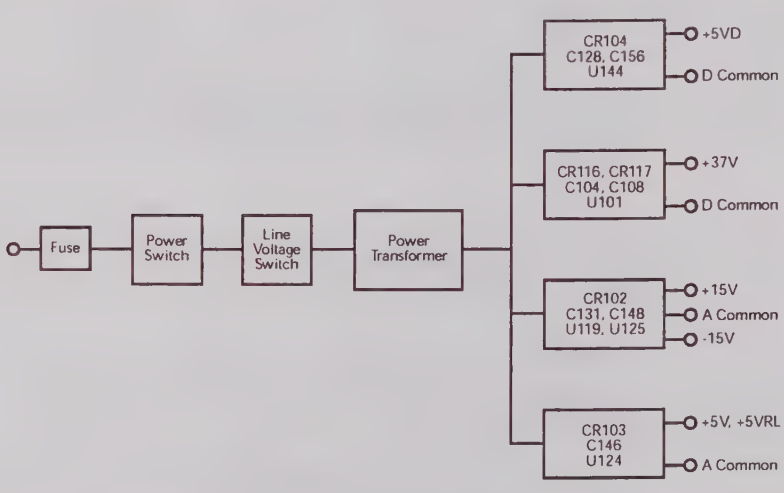
Key matrix

The front panel keys (S401-S430) are organized into a row-column matrix to minimize the number of microcontroller peripheral lines required to read the keyboard. A key is read by strobing the columns and reading all rows for each strobed column. Key down data is interpreted by the display microcontroller and sent back to the main microprocessor using proprietary encoding schemes.

Power supply

The following information provides some basic circuit theory that can be used as an aid to troubleshoot the power supply. A block diagram of the power supply is shown in Figure 2-1.

Figure 2-1
Power supply block diagram



AC power is applied to the AC power module receptacle (J1009). Power is routed through the line fuse and line voltage selection switch of the power module to the power transformer. The power transformer has a total of four secondary windings for the various supplies.

AC voltage for the display filaments is taken from a power transformer secondary at F1 and F2, and then routed to the display board.

Each DC supply uses a bridge rectifier, a capacitive filter arrangement and a regulator. Table 2-1 summarizes rectifier, filter and regulator circuits for the various supplies.

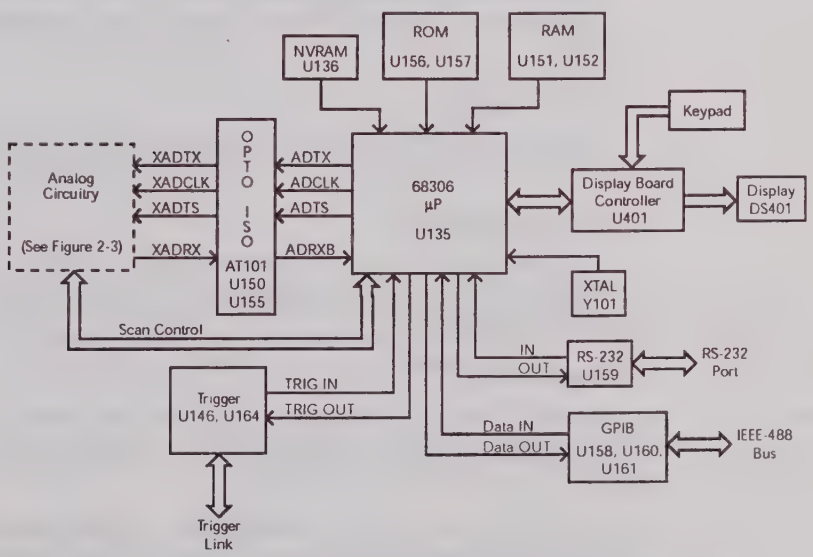
Table 2-1
Power supply circuits

Supply	Rectifier	Filter	Regulator
+5VD	CR104	C128, C156	U144
+37V	CR116, CR117	C104, C108	U101
+15V	CR102	C148	U125
-15V	CR102	C131	U119
+5V, +5VRL	CR103	C146	U124

Digital circuitry

Refer to Figure 2-2 for the following discussion on digital circuitry.

Figure 2-2
Digital circuitry block diagram



Microprocessor

U135 is a 68306 microprocessor that oversees all operating aspects of the instrument. The MPU has a 16-bit data bus and provides an 18-bit address bus. It also has parallel and serial ports for controlling various circuits. For example, the RXDA, TXDA, RXDB and TXDB lines are used for the RS-232 interface.

The MPU clock frequency of 14.7456MHz is controlled by crystal Y101. MPU RESET is performed momentarily (through C241) on power-up by the +5VD power supply.

Memory circuits

ROMs U156 and U157 store the firmware code for instrument operation. U157 stores the D0-D7 bits of each data word, and U156 stores the D8-D15 bits.

RAMS U151 and U152 provide temporary operating storage. U152 stores the D0-D7 bits of each data word, and U151 stores the D8-D15 bits.

Semi-permanent storage facilities include NVRAM U136. This IC stores such information as instrument setup and calibration constants. Data transmission from this device is done in a serial fashion.

RS-232 interface

Serial data transmission and reception is performed by the TXDB and RXDB lines of the MPU. U159 provides the necessary voltage level conversion for the RS-232 interface port.

IEEE-488 interface

U158, U160 and U161 make up the IEEE-488 interface. U158, a 9914A GPIA, takes care of routine bus overhead such as handshaking, while U160 and U161 provide the necessary buffering and drive capabilities.

Trigger circuits

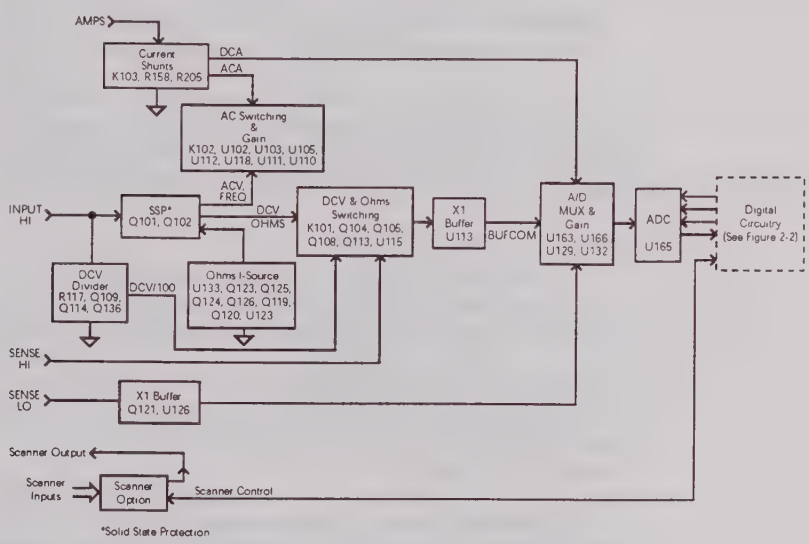
Buffering for Trigger Link input and output is performed by U146. Trigger input and output is controlled by the IRQ4 and PB3 lines of the MPU. U164 provides additional logic for the trigger input to minimize MPU control overhead.

At the factory, trigger output is connected to line 1 of the Trigger Link connector (resistor R267 installed). Trigger input is connected to line 2 of the Trigger Link connector (resistor R270 installed).

Analog circuitry

Refer to Figure 2-3 for the following discussion on analog circuitry.

Figure 2-3
Analog circuitry block diagram



INPUT HI

INPUT HI protection is provided by the SSP (solid state protection) circuit. The SSP is primarily made up of Q101 and Q102. An overload condition opens Q101 and Q102. This disconnects the analog input signal from the rest of the analog circuit.

Note that for the 100VDC and 1000VDC ranges, Q101 and Q102 of the SSP are open. The DC voltage signal is routed through the DCV Divider (Q114 and Q136 on) to the DCV switching circuit.

AMPS input

The ACA or DCA input signal is applied to the Current Shunt circuit, which is made up of K103, R158 and R205. For the 10mADC range, 10.1Ω (R158 + R205) is shunted across the input. Relay K103 is energized (on) to select the shunts. For all other DCA ranges, and all ACA ranges, 0.1Ω (R158) is shunted across the input (K103 off).

The ACA signal is then sent to the AC Switching & Gain circuit, while the DCA signal is routed directly to the A/D MUX & Gain circuit.

Signal switching

Signal switching for DCV and OHMS is done by the DCV & Ohms Switching circuit. FETs Q113, Q105, Q104 and Q108 connect the DCV or ohms signal to the ×1 buffer (U113). (Tables 2-5 through 2-8 show the switching states of these FETs for the various DCV and OHMS ranges.)

Note that the reference current for OHMS is generated by the Ohms I-Source circuit. For 4-wire ohms measurements, SENSE LO is connected to the circuit by turning on Q121.

Signal switching and gain for ACV, FREQ and ACA is done by the AC Switching & Gain circuit, which is primarily made up of K102, U102, U103, U105, U112, U118, U111 and U110. Tables 2-6 and 2-11 show the switching states for these AC signals. Note that U111 is used for frequency adjustment. The states of these analog switches vary from unit to unit.

Multiplexer and A/D converter

All input signals, except FREQ, are routed to the A/D MUX & Gain circuit. The multiplexer (U163) switches the various signals for measurement. In addition to the input signal, the multiplexer also switches among reference and zero signals at various phases of the measurement cycle.

When the input signal is selected by the MUX, it is amplified by U132 and U166. Tables 2-12 through 2-16 identify the input signal lines (S3, S4, S6 or S7) of the multiplexer for the various functions and ranges. These tables also provide the switch states of U129, which determine the gain for U132 and U166.

The multiplexed signals of the measurement cycle are routed to the A/D Converter (U165) where it converts the analog signals to digital form. The digital signals are then routed through an opto-isolator to the MPU to calculate a reading.

Display board checks

If the front panel DISP test indicates that there is a problem on the display board, use Table 2-2. See "Principles of Operation" for display circuit theory.

Table 2-2
Display board checks

Step	Item/component	Required condition	Remarks
1	Front panel DISP test.	Verify that all pixels operate.	Use front panel display test.
2	P1005, pin 5	+5V +/-5%	Digital +5V supply.
3	P1005, pin 9	+37V +/-5%	Display +37V supply.
4	U401, pin 1	Goes low briefly on power up, then goes low.	Microcontroller RESET.
5	U401, pin 43	4MHz square wave.	Controller 4MHz clock.
6	U401, pin 32	Pulse train every 1msec.	Control from main processor.
7	U401, pin 33	Brief pulse train when front panel key pressed.	Key down data sent to main processor.

Power supply checks

Power supply problems can be checked out using Table 2-3. See "Principles of Operation" for circuit theory on the power supply.

Table 2-3
Power supply checks

Step	Item/component	Required condition	Remarks
1	Line fuse	Check continuity.	Remove to check.
2	Line voltage	120V/240V as required.	Check power module position.
3	Line power	Plugged into live receptacle, power on.	Check for correct power-up sequence.
4	U144, pin2	+5V +/-5%	+5VD, referenced to Common D.
5	U101, pin 7	+37V +/-5%	+37V, referenced to Common D.
6	U125, pin 3	+15V +/-5%	+15V, referenced to Common A.
7	U119, pin 3	-15V +/-5%	-15V, referenced to Common A.
8	U124, pin 3	+5V +/-5%	+5VRL, referenced to Common A.

Digital circuitry checks

Digital circuit problems can be checked out using Table 2-4. See "Principles of Operation" for digital circuit.

Table 2-4
Digital circuitry checks

Step	Item/component	Required condition	Remarks
1	Power-on test	RAM OK, ROM OK.	Verify that RAM and ROM are functional.
2	U152 pin 16	Digital common.	All signals referenced to digital common.
3	U152 pin 32	+5V	Digital logic supply.
4	U135 pin 48	Low on power-up, then goes high.	MPU RESET line.
5	U135, lines A1 thru A23	Check for stuck bits.	MPU address bus.
6	U135, lines D1 thru D15	Check for stuck bits.	MPU data bus.
7	U135 pin 44	14.7456MHz	MPU clock.
8	U159 pin 13	Pulse train during RS-232 I/O.	RS-232 RX line.
9	U159 pin 14	Pulse train during RS-232 I/O.	RS-232 TX line.
10	U158 pins 34-42	Pulse train during IEEE-488 I/O.	IEEE-488 data bus.
11	U158 pins 26-31	Pulses during IEEE-488 I/O.	IEEE-488 command lines.
12	U158 pin 24	Low with remote enabled.	IEEE-488 REN line.
13	U158 pin 25	Low during interface clear.	IEEE-488 IFC line.
14	U135 pin 84	Pulse train.	ADRXB
15	U135 pin 91	Pulse train.	ADTX
16	U135 pin 90	Pulse train.	ADCLK
17	U135 pin 89	Pulse train.	ADTS

Analog signal switching states

Tables 2-5 through 2-11 provide switching states of the various relays, FETs and analog switches for the basic measurement functions and ranges. These tables can be used to assist in tracing an analog signal from the input to the A/D multiplexer.

Table 2-5
DCV signal switching

Range	Q101	Q102	Q114	Q136	Q109	K101*	Q113	Q105	Q104	Q108	Q121
100mV	ON	ON	OFF	OFF	OFF	SET	OFF	OFF	ON	OFF	ON
1V	ON	ON	OFF	OFF	OFF	SET	OFF	OFF	ON	OFF	ON
10V	ON	ON	OFF	OFF	OFF	SET	OFF	OFF	ON	OFF	ON
100V	OFF	OFF	ON	ON	OFF	SET	OFF	OFF	OFF	ON	ON
1000V	OFF	OFF	ON	ON	OFF	SET	OFF	OFF	OFF	ON	ON

*K101 set states: Pin 8 switched to Pin 7
Pin 3 switched to Pin 4

Table 2-6
ACV and FREQ signal switching

Range	Q101	Q102	K101*	K102*	U103 pin 8	U103 pin 9	U105 pin 9	U105 pin 8	U103 pin 16	U103 pin 1	U105 pin 1	U111 pin 16
100mV	ON	ON	RESET	RESET	ON	ON	OFF	OFF	OFF	ON	ON	OFF
1V	ON	ON	RESET	RESET	ON	ON	OFF	OFF	ON	OFF	OFF	OFF
10V	ON	ON	RESET	SET	OFF	OFF	ON	OFF	OFF	ON	ON	OFF
100V	ON	ON	RESET	SET	OFF	OFF	ON	OFF	ON	OFF	OFF	OFF
750V	ON	ON	RESET	SET	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF

*K101 and K102 reset states: Pin 8 switched to Pin 9
Pin 3 switched to Pin 2
K101 and K102 set states: Pin 8 switched to Pin 7
Pin 3 switched to Pin 4

Table 2-7
Ω2 signal switching

Range	Q101	Q102	Q114	Q136	Q109	K101*	K102*	Q113	Q105	Q104	Q108	Q121
100Ω	ON	ON	OFF	OFF	OFF	SET	RESET	OFF	ON	OFF	OFF	ON
1kΩ	ON	ON	OFF	OFF	OFF	SET	RESET	OFF	ON	OFF	OFF	ON
10kΩ	ON	ON	OFF	OFF	OFF	SET	RESET	OFF	ON	OFF	OFF	ON
100kΩ	ON	ON	OFF	OFF	OFF	SET	RESET	OFF	ON	OFF	OFF	ON
1MΩ	ON	ON	OFF	OFF	OFF	SET	RESET	OFF	ON	OFF	OFF	ON
10MΩ	ON	ON	OFF	OFF	ON	SET	RESET	OFF	ON	OFF	OFF	ON
100MΩ	ON	ON	OFF	OFF	ON	SET	RESET	OFF	ON	OFF	OFF	ON

*K101 set states: Pin 8 switched to Pin 7
Pin 3 switched to Pin 4
K102 reset states: Pin 8 switched to Pin 9
Pin 3 switched to Pin 2

Table 2-8
Ω4 signal switching

Range	Q101	Q102	Q114	Q136	Q109	K101*	Q113	Q105	Q104	Q108	Q121
100Ω	ON	ON	OFF	OFF	OFF	SET	ON	OFF	OFF	OFF	ON
1kΩ	ON	ON	OFF	OFF	OFF	SET	ON	OFF	OFF	OFF	ON
10kΩ	ON	ON	OFF	OFF	OFF	SET	ON	OFF	OFF	OFF	ON
100kΩ	ON	ON	OFF	OFF	OFF	SET	ON	OFF	OFF	OFF	ON
1MΩ	ON	ON	OFF	OFF	OFF	SET	ON	OFF	OFF	OFF	ON
10MΩ	ON	ON	OFF	OFF	ON	SET	OFF	ON	OFF	OFF	ON
100MΩ	ON	ON	OFF	OFF	ON	SET	OFF	ON	OFF	OFF	ON

*K101 set states: Pin 8 switched to Pin 7
Pin 3 switched to Pin 4

Table 2-9
Ω2/Ω4 reference switching

Range	U133 /.7V	U133 /7V	Q123	Q125	Q124	Q126	Q120
100Ω	OFF	ON	ON	ON	OFF	OFF	ON
1kΩ	OFF	ON	ON	ON	OFF	OFF	ON
10kΩ	OFF	ON	OFF	OFF	ON	ON	ON
100kΩ	ON	OFF	OFF	OFF	ON	ON	ON
1MΩ	ON	OFF	OFF	OFF	ON	ON	ON
10MΩ	OFF	ON	OFF	OFF	ON	ON	OFF
100MΩ	OFF	ON	OFF	OFF	ON	ON	OFF

Table 2-10
DCA signal switching

Range	K103
10mA	ON
100mA	OFF
1A	OFF
3A	OFF

Table 2-11
ACA signal switching

Range	K103	U105 pin 16	U105 pin 1	U111 pin 16	U105 pin 8	U103 pin 16	U103 pin 1
1A	OFF	ON	ON	OFF	OFF	OFF	OFF
3A	OFF	ON	ON	ON	OFF	OFF	OFF

Tables 2-12 through 2-16 can be used to trace the analog signal through the A/D multiplexer (U163) to the final amplifier stage. These tables show the MUX lines (S3, S4, S6, S7) that are selected for measurement during the SIGNAL phase of the multiplexing cycle. Also included are switching states of analog switches (U129) that set up the gain for the final amplifier stage (U166).

Table 2-12
DCV signal multiplexing and gain

Range	Signal (U163)	U129 pin 1	U129 pin 8	U129 pin 9	Gain (U166)
100mV	S4	OFF	OFF	ON	×100
1V	S4	OFF	ON	OFF	×10
10V	S4	ON	OFF	OFF	×1
100V	S4	OFF	ON	OFF	×10
1000V	S4	ON	OFF	OFF	×1

Table 2-13
ACV and ACA signal multiplexing and gain

Range	Signal (U163)	U129 pin 1	U129 pin 8	U129 pin 9	Gain (U166)
All	S3	ON	OFF	OFF	×1

Table 2-14
DCA signal multiplexing and gain

Range	Signal (U163)	U129 pin 1	U129 pin 8	U129 pin 9	Gain (U166)
10mA	S6	OFF	OFF	ON	×100
100mA	S6	OFF	OFF	ON	×100
1A	S6	OFF	OFF	ON	×100
3A	S6	OFF	ON	OFF	×10

Table 2-15
Ω2 signal multiplexing and gain

Range	Signal (U163)	U29 pin 1	U129 pin 8	U129 pin 9	Gain (U166)
100Ω	S4	OFF	OFF	ON	×100
1kΩ	S4	OFF	ON	OFF	×10
10kΩ	S4	OFF	ON	OFF	×10
100kΩ	S4	OFF	ON	OFF	×10
1MΩ	S4	ON	OFF	OFF	×1
10MΩ	S4	ON	OFF	OFF	×1
100MΩ	S4	ON	OFF	OFF	×1

Table 2-16
Ω4 signal multiplexing and gain

Range	Signal (U163)	U129 pin 1	U129 pin 8	U129 pin 9	Gain (U166)
100Ω	S4 then S7	OFF	OFF	ON	×100
1kΩ	S4 then S7	OFF	ON	OFF	×10
10kΩ	S4 then S7	OFF	ON	OFF	×10
100kΩ	S4 then S7	OFF	ON	OFF	×10
1MΩ	S4 then S7	ON	OFF	OFF	×1
10MΩ	S4 then S7	ON	OFF	OFF	×1
100MΩ	S4 then S7	ON	OFF	OFF	×1

Figure 2-3 provides a block diagram of the analog circuitry. Table 2-17 is provided to show where the various switching devices are located in the block diagram.

Table 2-17
Circuit section locations for switching devices

Switching devices	Analog circuit section (see Figure 2-3)
Q101, Q102	SSP (Solid State Protection)
Q114, Q136, Q109	DCV Divider
K101, Q113, Q105, Q104, Q108	DCV & Ohms Switching
Q121	Sense LO
K102, U103, U105, U111	AC Switching & Gain
U133, Q123, Q125, Q124, Q126, Q120	Ohms I-Source
K103	Current Shunts
U163, U129	A/D Mux & Gain

Built-In Test overview

Built-In Test is used to test and exercise various circuits and components. The Built-In Tests are listed in Table 2-18. Many of the tests are actual pass/fail type tests, while others are circuit exercises that are used for subsequent tests. Each Built-In Test can be run manually. After a test is manually run, operation is "frozen" to allow the technician to troubleshoot the circuit.

Using Built-In Test

There are several ways to run the Built-In Test, including the following recommended sequence:

1. Run the AUTO bit test (see "AUTO Testing") and note the first (lowest numbered) test that has failed. Always address the lowest numbered test failure first because that failure could cause subsequent tests to fail.
2. Familiarize yourself with the failed circuit. See "Built-In Test Documentation" for troubleshooting information. Be sure to read the documentation for the complete series. For example, if test 202.4 fails, read the documentation for all 202 series tests.
3. Manually run the test that failed (see "MANUAL Testing"). Keep in mind that many of the pass/fail type tests require that one or more circuit exercise tests be run first. Using the manual step looping mode will "freeze" instrument operation after a test is run.
4. After manually running the test, use the test documentation and your troubleshooting expertise to locate the problem.
5. After repairing the instrument, start again at step 1 to check the integrity of the repair and to see if there are any other failures.

Table 2-18
Built-In Test summary

Test	Circuit tested
Bank 100	A/D
100.1	A/D
100.2	A/D
101.1	TestCal
101.2	TestCal
101.3	TestCal
Bank 200	REF/MUX
200.1	Reference
200.2	Reference
201.1	A/D Mux Lo
201.2	A/D Mux Lo
Bank 300	DC/OHM
300.1	Front End Lo
301.1	Hi Ohms
301.2	Hi Ohms
302.1	2W Sense
302.2	2W Sense
303.1	Lo Ohm Path
303.2	Lo Ohm Path
304.1	Input /100
Bank 400	VAC
400.1	Non Inv Path
400.2	Non Inv Path
400.3	Non Inv Path
401.1	Invert Path
401.2	Invert Path
401.3	Invert Path
402.1	Non Inv /10
402.2	Non Inv /10
402.3	Non Inv /10
403.1	Non Inv Bex2
403.2	Non Inv Bex2
403.3	Non Inv Bex2
Bank 500	SENSE
500.1	4W Sense
500.2	4W Sense
Bank 600	AMP/OHM
600.1	Ohm/Amp
600.2	Ohm/Amp
601.1	Amp Shunt
601.2	Amp Shunt
601.3	Amp Shunt

AUTO testing

1. Press SHIFT and then TEST to access the self-test options.
2. Use the ▲ or ▼ key to display "TEST: BUILT-IN" and press ENTER.
3. Use the ▲ or ▼ key to display "BIT: AUTO" and press ENTER.
4. Use the ◄ , ► , ▲ or ▼ key to display the bank of tests that you wish to run and press ENTER. Test BANK selections include:

FULL	Perform all tests.
A/D	Perform tests on A/D converter.
REF/MUX	Perform tests on reference and multiplexer circuitry.
DC/OHM	Perform tests on DC and ohm circuitry.
VAC	Perform tests on AC volts circuitry.
SENSE	Perform tests on sense circuitry.
AMP/OHM	Perform tests on amp and ohm circuitry.

5. Use the ◄ , ► , ▲ or ▼ key to display one of the following FAULT options:

PAUSE	The tests will stop (pause) when a failure (FAULT) occurs.
CONT	The tests will not stop (continue) when a failure occurs.

6. Press ENTER and go to step A or B:
   A. If the PAUSE fault option was selected, the tests will start immediately. The tests stop at a failure (FAULT) and displays the test number of the failure. Press ENTER to continue the tests or press EXIT to abort the tests.
   B. If the CONT fault option was selected, use the ▲ or ▼ key to display one of the following REPEAT options and press ENTER to start the tests:

      NO Perform the specified tests and stop.

      YES Continuously repeat the specified tests.

      When a failure occurs, the "FAULT" message will be displayed. If the YES repeat option was selected, use the EXIT key when ready to stop the tests.
7. After the tests are finished, any failures are displayed. With the "FAILS" message displayed, use the ◄ , ► , ▲ or ▼ key to scroll through the test numbers of the failures.
8. When finished, use the EXIT key to back out of the test menu structure.

MANUAL testing

1. Press SHIFT and then TEST to access the self-test options.
2. Use the ▲ or ▼ key to display "TEST: BUILT-IN" and press ENTER.
3. Use the ▲ or ▼ key to display "BIT: MANUAL" and press ENTER.
4. Use the ◄ and ► keys, or the ▲ and ▼ keys to display the desired test series number. For example, if you wish to run test 302.2, display the series 302 test number as shown:

   MANUAL: 302

5. With the desired test series number displayed, press ENTER.
6. Use the ◄ , ► , ▲ or ▼ key to display one of the following looping modes and press ENTER:

   SINGLE — Performs all the tests in the specified series. The instrument displays the number of the test being run. If a failure occurs, the "FAULT" message appears and stays on for the remainder of the tests in the series. This testing process automatically stops after the last test in the series is completed. This test process can also be stopped by pressing EXIT. When EXIT is pressed, any test in process will be allowed to finish before aborting the testing process.

   CONTINUOUS — This looping mode continuously repeats all the tests in the specified series until the testing process is manually stopped. If a failure occurs, the "FAULT" message appears and stays on for the remainder of the tests in the series. This test process can be stopped by pressing EXIT. When EXIT is pressed, any test in process will be allowed to finish before aborting the testing process.

   STEP — Used to perform one test at a time. Each press of the ENTER key performs the displayed test. If a failure occurs, the "FAULT" message appears for that test. The instrument automatically aborts the testing process after the last test in the series is run. If you do not wish to run all the tests in the series, simply press EXIT after the desired test is run.
7. After the tests are finished, any failures are displayed. With the "FAILS" message displayed, use the ◄ , ► , ▲ or ▼ key to scroll through the test numbers of the failures.
8. When finished, use the EXIT key to back out of the test menu structure.

TEST BANK: REF/MUX

Test 200.1 — REFERENCE

Bank	REF/MUX
Inputs	Open
Expected Value	1 volt
Limits	0.1 volts
Fault Message	1VREF/AD X10

Description

The 7V REFHI signal is routed through R189 and R185, which forms a 0.014/1 voltage divider with R188. The 0.1V result (0.014 × 7V = 0.1V) is then applied to S1 of U163. The A0, A1 and A2 bit pattern on U163 is set to connect the S1 signal (0.1V) to the D output. The signal is then routed through R159, Q117 and R166 to the non-inverting input of op amp U166. A/D MUX (U166) is configured for ×10 gain (/×10 control line is low turning on U129 analog switch; pins 6 to 7). Feedback resistors R309 and R310 configure the ×10 gain. Measure 1V at AD_IN.

Bit patterns

Bit pattern				Register
Q Q 87654321 —U106— 110v1111	Q Q 87654321 —U109— 00101111	Q Q 87654321 —U134— 1v10000v —U130— 10000111	Q Q 87654321 —U121— 01110010	 ACDC_STB MUX_STB
IC pins: Q8=11, Q7=12, Q6=13, Q5=14, Q4=7, Q3=6, Q2=5, Q1=4				

Test 200.2 — REFERENCE

Bank	REF/MUX
Inputs	Open
Expected Value	10 volts
Limits	1 volt
Fault Message	AD X100

Description Same as test 200.1 except the A/D MUX is configured for ×100 gain (/ ×100 control line is low). The gain path is through U129 pin 10 to 11. Resistor network R271 is used to configure the x100 gain. Measure 10V at AD_IN.

Bit patterns

Bit pattern				Register
Q Q 87654321 —U106— 110v1111	Q Q 87654321 —U109— 00101111	Q Q 87654321 —U134— 1v10000v —U130— 10001011	Q Q 87654321 —U121— 01110010	 ACDC_STB MUX_STB
IC pins: Q8=11, Q7=12, Q6=13, Q5=14, Q4=7, Q3=6, Q2=5, Q1=4				

Test 201.1 — A/D MUX LO

Bank	REF/MUX
Inputs	Open
Expected Value	0 volts
Limits	0.0001 volts
Fault Message	SENSE LO 0

Description

Signal LO is routed through R181 and Q122 (/LOMUXA control line high) into unity gain amp U126. Signal LO is then routed to S7 of U163. The A0, A1 and A2 bit pattern on U163 connects S7 to the D output, which then routes signal LO through Q117 to U166.

The A/D MUX (U166) is configured for ×1 gain (/×1 control line low) by closing U129; pin 2 to 3. Measure 0V at AD_IN.

Bit patterns

Bit pattern				Register
Q Q 87654321 —U106— 110v1111	Q Q 87654321 —U109— 00101111	Q Q 87654321 —U134— 1v10000v —U130— 11011101	Q Q 87654321 —U121— 01110010	 ACDC_STB MUX_STB
IC pins: Q8=11, Q7=12, Q6=13, Q5=14, Q4=7, Q3=6, Q2=5, Q1=4				

Test 201.2 — A/D MUX LO

Bank	REF/MUX
Inputs	Open
Expected Value	0 volts
Limits	0.0001 volts
Fault Message	MUX LO

Description

This test is similar to test 201.1, except signal LO is routed through R274 to S8 of U163. Signal LO is then routed through Q117 to U166, which is configured for ×1 gain. Measure 0V at AD_IN.

Bit patterns

Bit pattern				Register
Q Q 87654321 —U106— 110v1111	Q Q 87654321 —U109— 00101111	Q Q 87654321 —U134— 1v10000v —U130— 11111101	Q Q 87654321 —U121— 01110010	 ACDC_STB MUX_STB
IC pins: Q8=11, Q7=12, Q6=13, Q5=14, Q4=7, Q3=6, Q2=5, Q1=4				

TEST BANK: DC/OHM

Test 300.1 — FRONT END LO

Bank	DC/OHM
Inputs	Open
Expected Value	0 volts
Limits	0.01 volts
Fault Message	FRONT END LO

Description

This test is for the DC volts front end LO path. Control line DIVLO is high making the U120 comparator output (pin 2) open collector. Q114 is on due to the gate being pulled low by R164. Signal LO is connected to SIG/100 through Q114 and divider R117.

The DIVTAP control line at U115 (pin 11) is pulled high to turn on Q108. This routes SIG/100 LO through Q108 to the unity gain buffer U113. The signal at the output of U113 is now called BUFCOM and goes through R314 to S4 of U163. It then goes to the A/D MUX which is configured for ×1 gain. Measure 0V at AD_IN.

Bit patterns

Bit pattern				Register
Q Q 87654321 —U106— 110v1111	Q Q 87654321 —U109— 00101111	Q Q 87654321 —U134— 1v10000v —U130— 10111101	Q Q 87654321 —U121— 01110001	 ACDC_STB MUX_STB
IC pins: Q8=11, Q7=12, Q6=13, Q5=14, Q4=7, Q3=6, Q2=5, Q1=4				

Test 301.1 — HI OHMS

Bank	DC/OHM
Inputs	Open
Expected Value	7 volts
Limits	0.7 volts
Fault Message	7V REFBOOT

Description

+7V is generated by buffering REFHI with op amp U139. This +7V, which is used by the ohms circuit as a voltage reference, is switched by U133 (/7V control line low) to op amp U123 which is a unity gain buffer.

The +7V reference, now labeled REFBOOT, is routed through R272, Q109 (/HIOHM control line low), the 9.9MΩ half of R117, Q101, Q102, K101 (RESETK2 control line high), R304, Q104 (LOV control line high) to U113. The unity gain output of U113 (BUFCOM) then goes to the A/D MUX as in test 300.1 with a gain of ×1. Measure +7V at AD_IN.

NOTE *K101 and K102 are latching relays. Any reference to their control line settings implies that this setting, normally high (+5V), may be present for less than 100 milliseconds. Remember this if attempting to troubleshoot these parts, especially when running the BIT test in the MANUAL STEP mode.*

Bit patterns

Bit pattern				Register
Q Q 87654321 —U106— 110v1111	Q Q 87654321 —U109— 00101111	Q Q 87654321 —U134— 1v10001v —U130— 10111101	Q Q 87654321 —U121— 10000100	 ACDC_STB MUX_STB
IC pins: Q8=11, Q7=12, Q6=13, Q5=14, Q4=7, Q3=6, Q2=5, Q1=4				

Test 301.2 — HI OHMS

Bank	DC/OHM
Inputs	Open
Expected Value	12.4 volts
Limits	0.5 volts
Fault Message	13.3 REFBOOT

Description

This test is the same as 301.1 except that the +13.3V ohms reference is tested. The +13.3V reference is generated by the same circuit as the +7V reference. 14V is routed through Q130 and then applied to a 1K/10K divider which is part of R271. The +13.3V divider output is routed through analog switch U133 (/.7V control line low) to op amp U123. The remainder of the path is the same as test 300.1.

The expected voltage at AD_IN would be +13.3V except that at the source lead of Q104 (labeled SOURCE) there is a clamping circuit. Back-to-back 11V zener diodes VR105 and VR106, and photo-coupler U107 clamp the voltage at the SOURCE node to about +12.4V. Measure +12.4V at AD_IN.

Bit patterns

Bit pattern				Register
Q Q 87654321 —U106— 110v1111	Q Q 87654321 —U109— 00101111	Q Q 87654321 —U134— 0v01001v —U130— 10111101	Q Q 87654321 —U121— 10000100	 ACDC_STB MUX_STB
IC pins: Q8=11, Q7=12, Q6=13, Q5=14, Q4=7, Q3=6, Q2=5, Q1=4				

Test 302.1 — 2W SENSE

Bank	DC/OHM
Inputs	Open
Expected Value	7 volts
Limits	0.7 volts
Fault Message	2W SENSE 7V

Description

The +7V reference is again switched to REFBOOT, and routed through R272, Q109, the 9.9MΩ half of divider R117, the parallel combination of R115, R324 and L109, and then through R113, R107, R103, R108, and K101. At this point, the reference is labeled 2WSEN_I.

Reference 2WSEN_I is then routed through K102 (control line SETK1 high) to the 2WSEN_O node. This node then goes through Q105 (2W control line high), to U113 (BUFCOM) and to the A/D MUX with ×1 gain. Measure +7V at AD_IN.

Bit patterns

Bit pattern				Register
Q Q 87654321 —U106— 110v1111	Q Q 87654321 —U109— 00011111	Q Q 87654321 —U134— 0v10000v —U130— 10111101	Q Q 87654321 —U121— 10000010	 ACDC_STB MUX_STB
IC pins: Q8=11, Q7=12, Q6=13, Q5=14, Q4=7, Q3=6, Q2=5, Q1=4				

Test 302.2 — 2W SENSE

Bank	DC/OHM
Inputs	Open
Expected Value	12.4 volts
Limits	0.5 volts
Fault Message	2W SENSE 13V

Description

Same as test 302.1 except the +13.3V reference is used. This voltage does not go through the ohms zener clamp path but is clipped by the A/D circuit itself at about 12.4V due to the fact that 13.3V approaches the power supply limits of the op amps. Measure +12.4V at AD_IN.

Bit patterns

Bit pattern				Register
Q Q 87654321 —U106— 110v1111	Q Q 87654321 —U109— 00011111	Q Q 87654321 —U134— 0v01000v —U130— 10111101	Q Q 87654321 —U121— 10000010	 ACDC_STB MUX_STB
IC pins: Q8=11, Q7=12, Q6=13, Q5=14, Q4=7, Q3=6, Q2=5, Q1=4				

Test 303.1 — LO OHM PATH

Bank	DC/OHM
Inputs	Open
Expected Value	7 volts
Limits	0.7 volts
Fault Message	7V SOURCE

Description

This test uses the ohms circuit. The +7V reference is switched to REF-BOOT by closing U133 (/7V line low). Q123 and Q125 are turned on by setting the OHMA control line high. +14V is applied directly to R194. Since Q123 is on, +7V appears on the other side of R194. As a result, the voltage drop across R194 (7.06kΩ) is 7V. A current of 1mA therefore flows through R194, Q125, Q119, CR114, and Q120 (/LOWOHM control line low).

The current (labeled OHM) then flows through R304, U107, VR106, and VR105 to LO. The +7V reference is routed through Q104, to BUFCOM, and on to the A/D MUX with a gain of ×1. Measure +7V at AD_IN.

Bit patterns

Bit pattern				Register
Q Q 87654321 —U106— 110v1111	Q Q 87654321 —U109— 00101111	Q Q 87654321 —U134— 0v10011v —U130— 10111101	Q Q 87654321 —U121— 01100100	 ACDC_STB MUX_STB
IC pins: Q8=11, Q7=12, Q6=13, Q5=14, Q4=7, Q3=6, Q2=5, Q1=4				

Test 303.2 — LO OHM PATH

Bank	DC/OHM
Inputs	Open
Expected Value	12.4 volts
Limits	0.5 volts
Fault Message	13.3V SOURCE

Description

This test is similar to test 303.1. The +13.3V reference is switched to REF-BOOT again by closing U133 pins 6 to 7. Q124 and Q126 are turned on by setting the OHMA control line low. +14V is applied to R195, and since Q124 is on, +13.3V appears on the other end of R195. The voltage across R195 (70.6KΩ) is 0.7V. 10μA therefore flows through R195, Q126, Q119, CR114, and Q120 (/LOWOHM control line low).

The current (labeled OHM) then flows through R304, U107, VR106, and VR105 to LO. This is again the clamping circuit described in test 301.2. The +12.4V reference is routed through Q104, to BUFCOM, and on to the A/D MUX with a gain of ×1. Measure +12.4V at AD_IN.

Bit patterns

Bit pattern				Register
Q Q 87654321 —U106— 110v1111	Q Q 87654321 —U109— 00101111	Q Q 87654321 —U134— 0v01001v —U130— 10111101	Q Q 87654321 —U121— 01100100	 ACDC_STB MUX_STB
IC pins: Q8=11, Q7=12, Q6=13, Q5=14, Q4=7, Q3=6, Q2=5, Q1=4				

Test 304.1 — INPUT /100

Bank	DC/OHM
Inputs	Open
Expected Value	7 volts
Limits	0.7 volts
Fault Message	INP SIG/100

Description

The ohms circuit current is set up the same as test 303.1. A 1mA current flows into the OHM node but instead of flowing into the clamping circuit, it flows through K101 (RESETK2 control line high) through Q102, Q101, R117, and Q114 to LO.

Resistor R117 is a 100 to 1 divider. Therefore, 0.07V (7V/100) is seen at the SIG/100 node. Q108 is turned on to switch the 0.07V through U113 (BUFCOM) to the A/D MUX which is configured for ×100 gain. Measure +7V at AD_IN.

Bit patterns

Bit pattern				Register
Q Q 87654321 —U106— 110v1111	Q Q 87654321 —U109— 00101111	Q Q 87654321 —U134— 1v10011v —U130— 10111011	Q Q 87654321 —U121— 10110001	 ACDC_STB MUX_STB
IC pins: Q8=11, Q7=12, Q6=13, Q5=14, Q4=7, Q3=6, Q2=5, Q1=4				

TEST BANK: VAC

Test 400.1 — NON INV PATH

Bank	VAC
Inputs	Open
Expected Value	<none specified>
Limits	<none specified>
Fault Message	<none>

Description

This test places the ACV front end in the non-inverting configuration. Logic levels for this configuration are as follows:

K102: /SETK1 low, /RESETK1 high
U103: Pins 8 and 9 low
U105: Pin 9 high

The signal path is from ACIN through K102 to the plus input of U102. Resistors R117 (9.9MΩ) and R146 (1.1MΩ) to form a +10 at the input. The feedback path for U102 is from the minus input through U103 (pins 6 and 7) to node ACFE. Node ACFE is connected to U112 through U103 (pin 1 low). Op amp U112 is configured for ×10 gain. The output of U112 is routed through U105 (pin 1 low). The signal is then coupled across C115 to U118. Analog switch U111 (pin 16 low) is closed to set up U118 for unity gain.

The output of U118 goes to U110 (TRMS converter) through the parallel combination of R129, C113 and C114. The output of the TRMS converter (OUT) is fed back through its own internal buffer. The buffer output signal (BUFF OUT) is then labeled AC_MED. The AC_MED signal is selected at U163 and fed to the A/D buffer (U166) through Q117. The A/D buffer is set up for ×1 gain through U129 (/×1 low). This test is a setup phase for the next test.

Bit patterns

Bit pattern				Register
Q Q 87654321 —U106— 110v1111	Q Q 87654321 —U109— 10011111	Q Q 87654321 —U134— 1v01000v —U130— 10011101	Q Q 87654321 —U121— 01110000	ACDC_STB MUX_STB
IC pins: Q8=11, Q7=12, Q6=13, Q5=14, Q4=7, Q3=6, Q2=5, Q1=4				

Test 400.2 — NON INV PATH

Bank	VAC
Inputs	Open
Expected Value	5.6 volts
Limits	0.6 volts
Fault Message	NON INV PATH

Description

The previous test sets up the circuit for this test. There is a routine in software that generates a waveform for the ACV tests. This is done by selecting the 13.3V reference by closing analog switch U133 (/.7V control line low). The reference is buffered by U123 is labeled REFBOOT.

The REFBOOT signal is switched into the front end through Q109 via U120 by toggling the /HIOHM line. This switching routine is done in firmware. Q114 and Q136 are turned ON (conducting to ground) by U120 (DIV-LO control line low). The 100kΩ leg of R117 acts as a pull-up and pull-down to clean up the switched signal REFBOOT.

The signal path continues through Q101, Q102 and K101 to ACIN. The switched ACIN signal (coupled across C105) is applied to the circuit described in test 400.1 and the measurement is made.

The input signal switching stops while the A/D takes the reading. Signal switching continues after the reading is done. There are delays before the reading is taken to ensure that the ACV section and filters have enough time to reach a charged full scale reading. In this phase, the switched signal can be traced through the circuit described in test 400.1. Measure 5.6 volts DC at A/D_IN.

Bit patterns

Bit pattern				Register
Q Q 87654321 —U106— 110v1111	Q Q 87654321 —U109— 10011111	Q Q 87654321 —U134— 1v01000v —U130— 10011101	Q Q 87654321 —U121— 01110000	 ACDC_STB MUX_STB
IC pins: Q8=11, Q7=12, Q6=13, Q5=14, Q4=7, Q3=6, Q2=5, Q1=4				

Test 400.3 — NON INV PATH

Bank	VAC
Inputs	Open
Expected Value	<none specified>
Limits	<none specified>
Fault Message	<none>

Description This phase resets the circuit to a known state and turns the waveform signal off. Subsequent tests require that the A/D be in the normal operating mode.

Bit patterns

Bit pattern				Register
Q Q 87654321 —U106— 101v0001	Q Q 87654321 —U109— 10011111	Q Q 87654321 —U134— 1v01000v —U130— 10011101	Q Q 87654321 —U121— 01110000	 ACDC_STB MUX_STB
IC pins: Q8=11, Q7=12, Q6=13, Q5=14, Q4=7, Q3=6, Q2=5, Q1=4				

Test 401.1 — INVERT PATH

Bank	VAC
Inputs	Open
Expected Value	<none specified>
Limits	<none specified>
Fault Message	<none>

Description

This test places the ACV front end in the inverting configuration. Logic levels for this configuration are as follows:

K102: /SETK1 high, /RESETK1 low
U103: Pins 8 and 9 high
U105: Pin 9 low

The signal path is from ACIN through C105, R104 and R105, which make up a 1.1MΩ input resistance to the minus input of op amp U102. The plus input of U102 is connected to AC common through R146. Feedback for U102 is provided by R106 (11kΩ). The output gain for U102 (seen at ACFE) is ×0.001 (R106/(R117+R104+R105)).

The output of U102 (ACFE) is routed through U103 (pin 1 low) to U112 which is configured for ×10 gain. The signal then goes through U105 (pin 1 low) and is coupled across C115 to U118 which is configured for ×2 gain.

The output of U118 goes to the TRMS converter (U110) through the parallel combination of R129, C113 and C114. The output of the TRMS converter (OUT) is fed back through its own internal buffer. The buffer output signal (BUFF OUT) is then labeled AC_MED. The AC_MED signal is selected at U163 and fed to the A/D buffer (U166) through Q117. The A/D buffer is set up for ×1 gain through U129 (/×1 low). This test is a setup phase for the next test.

Bit patterns

Bit pattern				Register
Q Q 87654321 —U106— 101v1101	Q Q 87654321 —U109— 01101111	Q Q 87654321 —U134— 1v01000v —U130— 10011101	Q Q 87654321 —U121— 01110000	ACDC_STB MUX_STB
IC pins: Q8=11, Q7=12, Q6=13, Q5=14, Q4=7, Q3=6, Q2=5, Q1=4				

Test 401.2 — INVERT PATH

Bank	VAC
Inputs	Open
Expected Value	0.108 volts
Limits	0.02 volts
Fault Message	INVERT PATH

Description

The previous test sets up the circuit for this test. There is a routine in software that generates a waveform for the ACV tests. This is done by selecting the 13.3V reference by closing analog switch U133 (/.7V control line low). The reference is buffered by U123 is labeled REFBOOT.

The REFBOOT signal is switched into the front end through Q109 via U120 by toggling the /HIOHM line. This switching routine is done in firmware. Q114 and Q136 are turned ON (conducting to ground) by U120 (DIV-LO control line low). The 100kΩ leg of R117 acts as a pull-up and pull-down to clean up the switched signal REFBOOT.

The signal path continues through Q101, Q102 and K101 to ACIN. The switched ACIN signal (coupled across C105) is applied to the circuit described in test 401.1 and the measurement is made.

The input signal switching stops while the A/D takes the reading. Signal switching continues after the reading is done. There are delays before the reading is taken to ensure that the ACV section and filters have enough time to reach a charged full scale reading. In this phase,the switched signal can be traced through the circuit described in test 401.1. Measure 108mV DC at A/D_IN.

Bit patterns

Bit pattern				Register
Q Q 87654321 —U106— 101v1101	Q Q 87654321 —U109— 01101111	Q Q 87654321 —U134— 1v01000v —U130— 10011101	Q Q 87654321 —U121— 01110000	ACDC_STB MUX_STB
IC pins: Q8=11, Q7=12, Q6=13, Q5=14, Q4=7, Q3=6, Q2=5, Q1=4				

Test 401.3 — INVERT PATH

Bank	VAC
Inputs	Open
Expected Value	<none specified>
Limits	<none specified>
Fault Message	<none>

Description This phase resets the circuit to a known state and turns the waveform signal off. Subsequent tests require that the A/D be in the normal operating mode.

Bit patterns

Bit pattern				Register
Q Q 87654321 —U106— 101v1101	Q Q 87654321 —U109— 01101111	Q Q 87654321 —U134— 1v01000v —U130— 10011101	Q Q 87654321 —U121— 01110000	 ACDC_STB MUX_STB
IC pins: Q8=11, Q7=12, Q6=13, Q5=14, Q4=7, Q3=6, Q2=5, Q1=4				

Test 402.1 — NON INV /10

Bank	VAC
Inputs	Open
Expected Value	<none specified>
Limits	<none specified>
Fault Message	<none>

Description

This test places the ACV front end in the non-inverting configuration. Logic levels for this configuration are as follows:

K102: /SETK1 low, /RESETK1 high
U103: Pins 8 and 9 low
U105: Pin 9 high

The signal path is from ACIN through K102 to the plus input of U102. Resistors R117 (9.9MÍ) and R146 (1.1MΩ) to form a +10 at the input. The feedback path for U102 is from the minus input through U103 (pins 6 and 7) to node ACFE.

The signal at ACFE is divided by 10 through R110 to make ACFE/10. The ACFE/10 signal bypasses U112 through U105 (pin 8 set LO). The signal is then coupled across C115 to U118 which is configured for ×2 gain.

The output of U118 goes to U110 (TRMS converter) through the parallel combination of R129, C113 and C114. The output of the TRMS converter (OUT) is fed back through its own internal buffer. The buffer output signal (BUFF OUT) is then labeled AC_MED. The AC_MED signal is selected at U163 and fed to the A/D buffer (U166) through Q117. The A/D buffer is set up for ×1 gain through U129 (/×1 low). This test is a setup phase for the next test.

Bit patterns

Bit pattern				Register
Q Q 87654321 —U106— 110v0011	Q Q 87654321 —U109— 11011111	Q Q 87654321 —U134— 1v01000v —U130— 10011101	Q Q 87654321 —U121— 01110000	 ACDC_STB MUX_STB
IC pins: Q8=11, Q7=12, Q6=13, Q5=14, Q4=7, Q3=6, Q2=5, Q1=4				

Test 402.2 — NON INV /10

Bank	VAC
Inputs	Open
Expected Value	0.108 volts
Limits	0.02 volts
Fault Message	NON INV /10

Description

The previous test sets up the circuit for this test. There is a routine in software that generates a waveform for the ACV tests. This is done by selecting the 13.3V reference by closing analog switch U133 (/.7V control line low). The reference is buffered by U123 is labeled REFBOOT.

The REFBOOT signal is switched into the front end through Q109 via U120 by toggling the /HIOHM line. This switching routine is done in firmware. Q114 and Q136 are turned ON (conducting to ground) by U120 (DIV-LO control line low). The 100kΩ leg of R117 acts as a pull-up and pull-down to clean up the switched signal REFBOOT.

The signal path continues through Q101, Q102 and K101 to ACIN. The switched ACIN signal (coupled across C105) is applied to the circuit described in test 402.1 and the measurement is made.

The input signal switching stops while the A/D takes the reading. Signal switching continues after the reading is done. There are delays before the reading is taken to ensure that the ACV section and filters have enough time to reach a charged full scale reading. In this phase, the switched signal can be traced through the circuit described in test 402.1. Measure 108mV DC at A/D_IN.

Bit patterns

Bit pattern				Register
Q Q 87654321 —U106— 110v0011	Q Q 87654321 —U109— 11011111	Q Q 87654321 —U134— 1v01000v —U130— 10011101	Q Q 87654321 —U121— 01110000	 ACDC_STB MUX_STB
IC pins: Q8=11, Q7=12, Q6=13, Q5=14, Q4=7, Q3=6, Q2=5, Q1=4				

Test 402.3 — NON INV /10

Bank	VAC
Inputs	Open
Expected Value	<none specified>
Limits	<none specified>
Fault Message	<none>

Description This phase resets the circuit to a known state and turns the waveform signal off. Subsequent tests require that the A/D be in the normal operating mode.

Bit patterns

Bit pattern				Register
Q Q 87654321 —U106— 110v0011	Q Q 87654321 —U109— 11011111	Q Q 87654321 —U134— 1v01000v —U130— 10011101	Q Q 87654321 —U121— 01110000	 ACDC_STB MUX_STB
IC pins: Q8=11, Q7=12, Q6=13, Q5=14, Q4=7, Q3=6, Q2=5, Q1=4				

Test 403.1 — NON INV BEX2

Bank	VAC
Inputs	Open
Expected Value	<none specified>
Limits	<none specified>
Fault Message	<none>

Description

This test places the ACV front end in the non-inverting configuration. Logic levels for this configuration are as follows:

K102: /SETK1 low, /RESETK1 high
U103: Pins 8 and 9 low
U105: Pin 9 high

The signal path is from ACIN through K102 to the plus input of U102. Resistors R117 (9.9MΩ) and R146 (1.1MΩ) to form a ÷10 at the input. The feedback path for U102 is from the minus input through U103 (pins 6 and 7) to node ACFE. The ACFE signal bypasses U112 through U103 (pin 16 low). The signal is then coupled across C115 to U118 which is configured for x2 gain.

The output of U118 goes to U110 (TRMS converter) through the parallel combination of R129, C113 and C114. The output of the TRMS converter (OUT) is fed back through its own internal buffer. The buffer output signal (BUFF OUT) is then labeled AC_MED. The AC_MED signal is selected at U163 and fed to the A/D buffer (U166) through Q117. The A/D buffer is set up for ×1 gain through U129 (/×1 low). This test is a setup phase for the next test.

Bit patterns

Bit pattern				Register
Q Q 87654321 —U106— 011v0011	Q Q 87654321 —U109— 11011111	Q Q 87654321 —U134— 1v01000v —U130— 10011101	Q Q 87654321 —U121— 01110000	ACDC_STB MUX_STB
IC pins: Q8=11, Q7=12, Q6=13, Q5=14, Q4=7, Q3=6, Q2=5, Q1=4				

Test 403.2 — NON INV BEX2

Bank	VAC
Inputs	Open
Expected Value	1.08 volts
Limits?	0.2 volts
Fault Message	NON INV BEX2

Description

The previous test sets up the circuit for this test. There is a routine in software that generates a waveform for the ACV tests. This is done by selecting the 13.3V reference by closing analog switch U133 (/.7V control line low). The reference is buffered by U123 is labeled REFBOOT.

The REFBOOT signal is switched into the front end through Q109 via U120 by toggling the /HIOHM line. This switching routine is done in firmware. Q114 and Q136 are turned ON (conducting to ground) by U120 (DIV-LO control line low). The 100kΩ leg of R117 acts as a pull-up and pull-down to clean up the switched signal REFBOOT.

The signal path continues through Q101, Q102 and K101 to ACIN. The switched ACIN signal (coupled across C105) is applied to the circuit described in test 403.1 and the measurement is made.

The input signal switching stops while the A/D takes the reading. Signal switching continues after the reading is done. There are delays before the reading is taken to ensure that the ACV section and filters have enough time to reach a charged full scale reading. In this phase, the switched signal can be traced through the circuit described in test 403.1. Measure 1.08V DC at A/D_IN.

Bit patterns

Bit pattern				Register
Q Q 87654321 —U106— 011v0011	Q Q 87654321 —U109— 11011111	Q Q 87654321 —U134— 1v01000v —U130— 10011101	Q Q 87654321 —U121— 01110000	ACDC_STB MUX_STB
IC pins: Q8=11, Q7=12, Q6=13, Q5=14, Q4=7, Q3=6, Q2=5, Q1=4				

Test 403.3 — NON INV BEX2

Bank	VAC
Inputs	Open
Expected Value	<none specified>
Limits	<none specified>
Fault Message	<none>

Description This phase resets the circuit to a known state and turns the waveform signal off. Subsequent tests require that the A/D be in the normal operating mode.

Bit patterns

Bit pattern				Register
Q Q 87654321 —U106— 011v0011	Q Q 87654321 —U109— 11011111	Q Q 87654321 —U134— 1v01000v —U130— 10011101	Q Q 87654321 —U121— 01110000	 ACDC_STB MUX_STB
IC pins: Q8=11, Q7=12, Q6=13, Q5=14, Q4=7, Q3=6, Q2=5, Q1=4				

TEST BANK: SENSE

Test 500.1 — 4W SENSE

Bank	SENSE
Inputs	4-wire short
Expected Value	0 volts
Limits	0.0001 volts
Fault Message	SENSE LO

Description

This test requires a 4-wire short at the input. The SLO node is the Sense LO jack on the front or rear panel. The 4-wire short connects SLO to LO. The 0V signal at SLO is routed through R132, R139, R148, R163, and Q121 to U126, which is configured as a unity gain buffer. The 0V output of U126 is routed to S7 of U163 where it is switched to the A/D MUX (×1 gain). Measure 0V at AD_IN.

Bit patterns

Bit pattern				Register
Q Q 87654321 —U106— 110v1111	Q Q 87654321 —U109— 00101111	Q Q 87654321 —U134— 1v10000v —U130— 01011101	Q Q 87654321 —U121— 01110010	 ACDC_STB MUX_STB
IC pins: Q8=11, Q7=12, Q6=13, Q5=14, Q4=7, Q3=6, Q2=5, Q1=4				

Test 500.2 — 4W SENSE

Bank	SENSE
Inputs	4-wire short
Expected Value	0 volts
Limits	0.0001 volts
Fault Message	SENSE HI

Description

This test requires a 4-wire short at the input. The SHI node is the Sense HI jack on the front or rear panel. The 4-wire short connects SHI to LO. The 0V signal at SHI is routed through R120, R124, R121, R125 and Q113 (4W control line high) to U113 BUFCOM. As in previous tests, this signal goes to the A/D MUX which is configured for ×1 gain. Measure 0V at AD_IN.

Bit patterns

Bit pattern				Register
Q Q 87654321 —U106— 110v1111	Q Q 87654321 —U109— 00101111	Q Q 87654321 —U134— 1v10000v —U130— 10111101	Q Q 87654321 —U121— 01101000	 ACDC_STB MUX_STB
IC pins: Q8=11, Q7=12, Q6=13, Q5=14, Q4=7, Q3=6, Q2=5, Q1=4				

TEST BANK: AMP/OHM

Test 600.1 — OHM/AMP

Bank	AMP/OHM
Inputs	INPUT HI to AMPS Short
Expected Value	0.0095 volts
Limits	0.001 volts
Fault Message	1mA SOURCE

Description

This test requires a jumper wire from the INPUT HI jack to the AMPS jack on the front panel. The +7V reference is switched to the ohms circuit through U133. Q123 and Q125 are turned on to generate a 1mA current that is routed to the INPUT HI jack. The signal path for this 1mA current is from the +14V node through R194, Q125, Q119, Q120, K101 (pins 3 to 4) Q102, Q101, through the parallel combination of R115, L109, and R324, then to the INPUT HI jack.

The jumper wire then routes the 1mA into the AMPS jack through K103 (SETK3 control line high so that pins 3 to 4 and 7 to 8 are closed). This puts R205 in series with R158 for a total of 10.1Ω. The 1mA current through 10.1Ω generates around 10mV which is sensed through S101 and R142 to the AMPSHUNT node. The AMPSHUNT signal is routed to S6 of U163 where it is switched to the A/D MUX. The A/D MUX is configured for ×1 gain. Measure 10mV at AD_IN.

Bit patterns

Bit pattern				Register
Q Q 87654321 —U106— 110v1111	Q Q 87654321 —U109— 00101111	Q Q 87654321 —U134— 1v10111v —U130— 11101101	Q Q 87654321 —U121— 10110010	ACDC_STB MUX_STB
IC pins: Q8=11, Q7=12, Q6=13, Q5=14, Q4=7, Q3=6, Q2=5, Q1=4				

Test 600.2 — OHM/AMP

Bank	AMP/OHM
Inputs	INPUT HI to AMPS short
Expected Value	0.025 volts
Limits	0.015 volts
Fault Message	.1 OHM SHUNT

Description

This test requires a jumper wire from the INPUT HI jack to the AMPS jack on the front panel. The +7V reference is switched to the ohms circuit through U133. Q123 and Q125 are turned on to generate a 1mA current that is routed to the INPUT HI jack. The signal path for this 1mA current is from the +14V node through R194, Q125, Q119, Q120, K101 (pins 3 to 4) Q102, Q101, through the parallel combination of R115, L109, and R324, then to the INPUT HI jack.

The jumper wire then routes the 1mA into the AMP jack and through K103 (SETK3 control line low so that pins 2 to 3 and 8 to 9 are closed). This bypasses R205 and routes the 1mA through the 0.1Ω ohm resistor (R158). A 1mA current through 0.1Ω generates around 100μV which is sensed through S101 and R142 to the AMPSHUNT node.

The AMPSHUNT signal is routed to S6 of U163 where it is switched to the A/D MUX. The A/D MUX is configured for ×100 gain. Since this is a very small voltage, trace resistance and circuit offsets greatly affect the expected voltage of 10mV. This test is useful to detect the presence of the proper component operation and not so much their precision. Measure approximately 25mV at AD_IN.

Bit patterns

Bit pattern				Register
Q Q 87654321 —U106— 110v1111	Q Q 87654321 —U109— 00101111	Q Q 87654321 —U134— 1v10011v —U130— 11101011	Q Q 87654321 —U121— 10110010	 ACDC_STB MUX_STB
IC pins: Q8=11, Q7=12, Q6=13, Q5=14, Q4=7, Q3=6, Q2=5, Q1=4				

Test 601.1 — AMP SHUNT

Bank	AMP/OHM
Inputs	INPUT HI to AMPS short
Expected Value	<none specified>
Limits	<none specified>
Fault Message	<none>

Description

This test requires an external jumper wire be installed from the INPUT HI jack to the AMPS jack on the front panel. There is a routine in software that generates a test signal current for the ACV AMP test. This signal generation is described in test 601.2.

The test signal is routed through the front end circuit to the front panel INPUT HI jack. The jumper connects the test signal to the front panel AMPS jack. The test signal is routed through K103 (pins 3 and 8 to pins 4 and 7. The signal current then flows through the series combination of R205 (10Ω) and R158 (0.1Ω) to ground. This generates an AC voltage that is connected to AMPSHNT through S101 and R142.

The ACV front end is set up for the non-inverting configuration as follows:

K102: /SETK1 low, /RESETK1 high
U103: Pins 8 and 9 low
U105: Pin 9 high

The AMPSHNT signal is routed through U105 (pin 16 low) to the plus input of U112 which is configured for ×10 gain. The output signal of the op amp is routed through U105 (pin 1 low) and coupled across C115 to U118 which is configured for ×2 gain.

The output of U118 goes to U110 the TRMS converter through R129 and the parallel C113 and C114. U110 OUT pin 11 is feed through its own internal buffer pin 1 to 16 and the signal out is AC_MED. AC_MED signal is selected at U163 pin 6 to 8 and fed to A/D buffer U166 through Q117. The A/D buffer is set up for ×1 gain through U129 pin 3 to 2 with /×1 low. This test is the setup phase for the next test phase.

Bit patterns

Bit pattern				Register
Q Q 87654321 —U106— 110v0010	Q Q 87654321 —U109— 11011111	Q Q 87654321 —U134— 1v10110v —U130— 10011101	Q Q 87654321 —U121— 10110000	 ACDC_STB MUX_STB
IC pins: Q8=11, Q7=12, Q6=13, Q5=14, Q4=7, Q3=6, Q2=5, Q1=4				

Test 601.2 — AMP SHUNT

Bank	AMP/OHM
Inputs	INPUT HI to AMPS Short
Expected Value	0.084 volts
Limits	0.02 volts
Fault Message	AC AMP SHUNT

Description

The previous test sets up the circuit for this test. There is a routine in software that generates a waveform for the ACV tests. This is done by selecting the 7V reference by closing analog switch U133 (/7V controlline low). The reference is buffered by U123.

Control line OHMA line is high turning Q123 and Q125 on which generates a 1mA current source with R195, op amp U123, Q119, and associated circuitry. The /LOWOHM control line of U133 is switched to toggle Q120 on and off to generate the 1mA AC current to the OHM node.

This test current is then switched through K101 (pin 4 to 3). Control line /SETK2 is high and /RESETK2 is low. The test current goes through Q102, Q101, the parallel combination of R115, L109, and R324, then to the INPUT HI jack.

The switched current signal is applied to the circuit described in the previous test and a measurement is made. The input signal switching stops while the A/D is taking the reading, then continues when the measurement is complete. There are delays before the reading is taken to ensure that the ACV section and filters have enough time to reach a charged stable reading. For this test, the switched signal can be traced through the circuit described in the previous test. Measure 84mV DC at A/D_IN.

Bit patterns

Bit pattern				Register
Q Q 87654321 —U106— 101v0010	Q Q 87654321 —U109— 11011111	Q Q 87654321 —U134— 1v10110v —U130— 10011101	Q Q 87654321 —U121— 10110000	ACDC_STB MUX_STB
IC pins: Q8=11, Q7=12, Q6=13, Q5=14, Q4=7, Q3=6, Q2=5, Q1=4				

Test 601.3 — AMP SHUNT

Bank	AMP/OHM
Inputs	INPUT HI to AMPS Short
Expected Value	<none specified>
Limits	<none specified>
Fault Message	<none>

Description

This phase resets the circuit to a known state and turns the waveform signal off. Subsequent tests require that the A/D be in the normal operating mode.

Bit patterns

Bit pattern				Register
Q Q 87654321 —U106— 101v0010	Q Q 87654321 —U109— 11011111	Q Q 87654321 —U134— 1v10110v —U130— 10011101	Q Q 87654321 —U121— 10110000	 ACDC23 _STB MUX_STB
IC pins: Q8=11, Q7=12, Q6=13, Q5=14, Q4=7, Q3=6, Q2=5, Q1=4				

3
Disassembly

Introduction

This section explains how to handle, clean, and disassemble the Model 2000 Multimeter. This section is organized as follows:

- Handling and cleaning — Describes how to properly handle, clean, and solder PC boards.
- Static sensitive devices — Explains how to handle ICs and CMOS devices.
- Assembly drawings — Provides mechanical drawings to assist in the disassembly and re-assembly of the Model 2000.
- Case cover removal — Provides the procedure for removing the case to gain access to the internal components.
- Motherboard removal — Provides the procedure for removing the motherboard.
- Front panel disassembly — Provides the procedure for removing the display board and front panel switch pad.
- Firmware replacement — Provides the procedure for removing and replacing the Model 2000 firmware.
- Removing power components — Explains how to remove the power transformer and power module.
- Instrument re-assembly — Provides general guidelines for re-assembling the Model 2000.

Handling and cleaning

To avoid contaminating PC board traces with body oil or other foreign matter, avoid touching the PC board traces while you are repairing the instrument. Motherboard areas covered by the shield have high impedance devices or sensitive circuitry where contamination could cause degraded performance.

Handling PC boards

Observe the following precautions when handling PC boards:

- Wear cotton gloves.
- Only handle PC boards by the edges and shields.
- Do not touch any board traces or components not associated with repair.
- Do not touch areas adjacent to electrical contacts.
- Use dry nitrogen gas to clean dust off PC boards.

Solder repairs

Observe the following precautions when you must solder a circuit board:

- Use an OA-based (organic activated) flux, and take care not to spread the flux to other areas of the circuit board.
- Remove the flux from the work area when you have finished the repair by using pure water with clean, foam-tipped swabs or a clean, soft brush.
- Once you have removed the flux, only swab the repair area with methanol, then blow dry the board with dry nitrogen gas.
- After cleaning, allow the board to dry in a 50°C, low-humidity environment for several hours.

Static sensitive devices

CMOS devices operate at very high impedance levels for low power levels. Therefore, any static that builds up on you or your clothing may be sufficient to destroy these devices if they are not handled properly. Use the following precautions to avoid damaging them:

CAUTION ***Many CMOS devices are installed in the Model 2000. Handle all semiconductor devices as static sensitive.***

- Only transport and handle ICs in containers specially designed to prevent static build-up. Typically, you receive these parts in anti-static containers made of plastic or foam. Keep these devices in their original containers until ready for installation.
- Remove the devices from their protective containers only at a properly grounded work station. Also, ground yourself with a suitable wrist strap.
- Handle the devices only by the body; do not touch the pins.
- Also ground any printed circuit board into which a semiconductor device is to be inserted to the bench or table.
- Only use anti-static type solder sucker.
- Only use grounded tip solder irons.
- Once the device is installed in the PC board, it is normally adequately protected, and you can handle the boards normally.

Assembly drawings

Use the following assembly drawings to assist you as you disassemble and re-assemble the Model 2000. Also, refer to these drawings for information about the Keithley part numbers of most mechanical parts in the unit. The drawings are located at the end of this section of the manual.

- Front Panel Assembly — 2000-040
- Chassis/Transformer Power Module Assembly — 2000-050
- Front Panel/Chassis Assembly — 2000-051
- Chassis Assembly — 2000-052

Case cover removal

If you need to troubleshoot the instrument or replace a component, you must gain access to the components by removing the case.

WARNING ***Before removing the case cover, disconnect the line cord and any test leads from the instrument.***

1. Remove Handle — The handle serves as an adjustable tilt-bail. Adjust its position by gently pulling it away from the sides of the instrument case and swinging it up or down. To remove the handle, swing the handle below the bottom surface of the case and back until the orientation arrows on the handles line up with the orientation arrows on the mounting ears. With the arrows lined up, pull the ends of the handle from the case.
2. Remove Mounting Ears — Remove the screw that secures each mounting ear. Pull down and out on each mounting ear.

NOTE *When re-installing the mounting ears, make sure to mount the right ear to the right side of the chassis, and the left ear to the left side of the chassis. Each ear is marked "RIGHT" or "LEFT" on its inside surface.*

3. Remove Rear Bezel — To remove the rear bezel, loosen the two captive screws that secure the rear bezel to the chassis. Pull the bezel away from the case.
4. Removing Grounding Screws — Remove the two grounding screws that secure the case to the chassis. They are located on the bottom of the case at the back.
5. Remove Chassis — To remove the case, grasp the front bezel of the instrument, and carefully slide the chassis forward. Slide the chassis out of the metal case.

NOTE *If you need to gain access to the components under the motherboard shield to troubleshoot them, remove the shield. It is secured to the motherboard by a single screw.*

Changing trigger link lines

The Model 2000 uses two lines of the Trigger Link rear panel connector as External Trigger (EXT TRIG) input and Voltmeter Complete (VMC) output. At the factory, line 1 is configured as VMC and line 2 as EXT TRIG.

NOTE *Line 1, 3 or 5 of the Trigger Link can be configured as VMC, while line 2, 4 or 6 can be configured as EXT TRIG.*

Trigger link line configurations are changed by moving the position of resistors inside the unit. Perform the following steps to change trigger link lines:

WARNING ***Make sure the instrument is disconnected from the power line and other equipment before performing the following procedure.***

1. Remove the cover from the instrument as explained in "Case Cover Removal".

   The resistors used to select the trigger link lines are located next to the Trigger Link connector as shown in Figure 3-1. The "resistors" are actually solder beads that bridge pc-board pads. If the factory default lines are selected, the solder beads will be located at R270 (line 2, EXT TRIG) and R267 (line 1, VMC).

2. To change a trigger link line:
   A. Use a soldering iron and solder sucker to remove the appropriate solder bead.
   B. Using a solder with OA-based flux, apply a solder bead to the appropriate resistor location.
3. Replace the cover on the instrument.

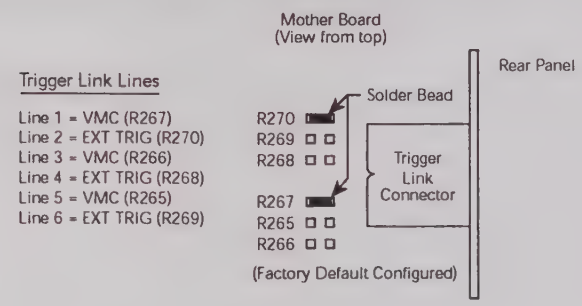


Figure 3-1
Trigger link line connections

Motherboard removal

Perform the following steps to remove the motherboard. This procedure assumes that the case cover is already removed.

1. Remove the IEEE-488 and RS-232 fasteners.

   The IEEE-488 and the RS-232 connectors each have two nuts that secure the connectors to the rear panel. Remove these nuts.

2. Remove the front/rear switch rod.

   At the switch, place the edge of a flat-blade screw driver in the notch on the pushrod. Gently twist the screw driver while pulling the rod from the shaft.

3. Disconnect the front and rear input terminals.

   You must disconnect these input terminal connections for both the front and rear inputs:

   - INPUT HI and LO
   - SENSE HI and LO
   - AMPS

Remove all the connections except the front AMPS connection by pulling the wires off the pin connectors. To remove the front panel AMPS input wire (white), first remove the AMPS fuse holder, then use needle-nose pliers to grasp the AMP wire near fuse housing. Push the wire forward and down to snap the spring out of the fuse housing. Carefully pull the spring and contact tip out of housing.

During re-assembly, use the following table to identify input terminals:

	Front wire color	Rear wire color
INPUT HI	Red	White/Red
INPUT LO	Black	White/Black
SENSE HI	Yellow	White/Yellow
SENSE LO	Gray	White/Gray
AMPS	White	—

4. Unplug cables.
   C. Unplug the display board ribbon cable from connector J1014.
   D. Unplug the transformer cables from connectors J1016 and J1015.
   E. Unplug the scanner board ribbon cable from connector J1017.
5. Remove the fastening screw that secures the main PC board to the chassis. This screw is located along the left side of the unit towards the rear. It also holds down U144.

   During re-assembly, replace the board, and start the IEEE-488 and RS-232 connector nuts and the mounting screw. Tighten all the fasteners once they are all in place and the board is correctly aligned.
6. Remove the motherboard, which is held in place by edge guides on each side, by sliding it forward until the board edges clear the guides. Carefully pull the motherboard from the chassis.

Front panel disassembly

Use the following procedures to remove the display board and/or the pushbutton switch pad:

NOTE *You must first remove the case cover, the front/rear input switch, and the front input terminal wires as described in earlier in this section.*

1. Unplug the display board ribbon cable from connector J1014.
2. Remove the front panel assembly.

   This assembly has four retaining clips that snap onto the chassis over four pem nut studs. Two retaining clips are located on each side of the front panel. Pull the retaining clips outward and, at the same time, pull the front panel assembly forward until it separates from the chassis.
3. Using a thin-bladed screw driver, pry the plastic PC board stop (located at the bottom of the display board) until the bar separates from the casing. Pull the display board from the front panel.
4. Remove the switch pad by pulling it from the front panel.

Main CPU firmware replacement

Changing the firmware may be necessary as upgrades become available. The firmware revision level for the main CPU is displayed during the power-on sequence. The firmware for the main CPU is located in the EPROMs U156 (EVEN) and U157 (ODD), leadless ICs that resides in chip carriers on the PC board.

To replace the CPU firmware, do the following:

WARNING ***Disconnect the instrument from the power lines and remove the test leads before changing the firmware.***

1. Remove the case cover as described earlier in this section.
2. Locate U156 EVEN and U157 ODD (EPROMs) on the main PC board. They are the only devices installed in chip carriers (sockets).

CAUTION ***EPROMs U156 and U157 are static sensitive devices. Be sure to follow the handling precautions explained in the paragraph entitled "Static sensitive devices."***

3. Using an appropriate chip extractor, remove U156 and U157 from its chip carrier.
4. Position the new U156 EPROM on the appropriate chip carrier. Make sure the notched corner of the chip is aligned with the notch in the chip carrier.
5. With the EPROM properly positioned, push down on the chip until it completely seats into the chip carrier.
6. Repeat steps 4 and 5 for EPROM U157.

Removing power components

The following procedures to remove the power transformer and/or power module require that the case cover and motherboard be removed, as previously explained.

Power transformer removal

Perform the following steps to remove the power transformer:

1. Remove motherboard.
2. Unplug the transformer wires that attach to the power module at the rear panel.

   During re-assembly, use drawing 2000-050 as a reference and replace the wires as follows:

Top wire	Gray
Right top	Violet
Right bottom	White
Left top	Red
Left bottom	Blue

3. Remove the two nuts that secure the transformer to the bottom of the chassis.
4. Pull the black ground wire off the threaded stud and remove the power transformer from the chassis.

WARNING ***To avoid electrical shock, which could result in injury or death, the black ground wire of the transformer must be connected to chassis ground. When installing the power transformer, be sure to re-connect the black ground wire to the mounting stud on bottom of the chassis.***

Power module removal

Perform the following steps to remove the power module:

1. Remove motherboard.
2. Unplug the transformer wires that attach to the power module at the rear panel.

   During re-assembly, use drawing 2000-050 as a reference and replace the wires as follows:

Top wire	Gray
Right top	Violet
Right bottom	White
Left top	Red
Left bottom	Blue

3. Disconnect the power module's ground wire. This green and yellow wire connects to a threaded stud on the chassis with a kep nut.
4. Squeeze the latches on either side of the power module while pushing the module from the access hole.

WARNING ***To avoid electrical shock, which could result in injury or death, the ground wire of the power module must be connected to chassis ground. When installing the power module, be sure to re-connect the green and yellow ground wire to the threaded stud on the chassis.***

Instrument re-assembly

Re-assemble the instrument by reversing the previous disassembly procedures. Make sure that all parts are properly seated and secured and that all connections are properly made. To ensure proper operation, replace and securely fasten the shield.

WARNING ***To ensure continued protection against electrical shock, verify that power line ground (green and yellow wire attached to the power module) and the power transformer ground (black wire) are connected to the chassis.***

4
Replaceable Parts

Introduction

This section contains replacement parts information and component layout drawings for the Model 2000.

Parts list

The electrical parts lists for the Model 2000 are shown in Tables 4-1 to 4-3. For part numbers to the various mechanical parts and assemblies, use the Miscellaneous parts list and the assembly drawings provided at the end of Section 3.

Ordering information

To place an order, or to obtain information concerning replacement parts, contact your Keithley representative or the factory (see inside front cover for addresses). When ordering parts, be sure to include the following information:

- Instrument model number (Model 2000)
- Instrument serial number
- Part description
- Component designation (if applicable)
- Keithley part number

Factory service

If the instrument is to be returned to Keithley Instruments for repair, perform the following:

1. Call the Repair Department at 1-800-552-1115 for a Return Material Authorization (RMA) number.
2. Complete the service form at the back of this manual, and include it with the instrument.
3. Carefully pack the instrument in the original packing carton.
4. Write ATTENTION REPAIR DEPARTMENT and the RMA number on the shipping label.

Components layouts

The component layouts are provided in the following pages:

Motherboard: 2000-250, pages 1 and 2
Connector board: 2000-250, pages 1 and 2
Display board: 2000-250, pages 3 and 4

Table 4-1
Model 2000 connector board, parts list

Circuit desig.	Description	Keithley part no.
C101	CAP, .1UF, 10%, 25V, CERAMIC (0805)	C-495-.1
J1034	CONN, MALE RT ANGLE, 32-PIN	CS-456
P1017	CABLE ASSEMBLY	CA-123-14A
R196	RES, 2.21K, 1%, 100MW, THICK FILM (0805)	R-418-2.21K

Table 4-2
Model 2000 display board, parts list

Circuit desig.	Description	Keithley part no.
	RFI CLIP, CHASSIS	2001-366-1A
	TAPE, 3/4 WIDE X 1/32 THICK	TP-12-1
C401,402,411	CAP,.1UF, 20%,50V,CERAMIC(1206)	C-418-.1
C403,404,405,407,409,410,412	CAP, .1UF, 10%, 25V, CERAMIC (0805)	C-495-.1
C406,408	CAP, 33PF, 10%, 100V, CERAMIC (1206)	C-451-33P
C413	CAP,22UF, 20%, 6.3,TANTALUM(C6032)	C-417-22
CR401,402	DIODE, MBR0520LT1(SOD-123)	RF-103
DS401	DISPLAY	DD-52
P1014	CABLE ASSEMBLY	CA-123-16A
R401,402,403,404,406,409,411	RES, 15k, 1%, 100MW, THICK FILM(0805)	R-418-15K
R405,408,410,412	RES, 12.1, 1%, 125MW METAL FILM(1206)	R-391-12.1
R413	RES, 13K, 1%, 100MW, THICK FILM(0805)	R-418-13K
R417,418	RES, 15k, 1%, 100MW, THICK FILM(0805)	R-418-15K
R419	RES, 10M, 5%, 125MW, METAL FILM(1206)	R-375-10M
R420,421	RES, 10K, 1%, 100MW, THICK FILM (0805)	R-418-10K
U401	PROGRAM	2000-800-**
U402,403	IC, LATCHED DRIVERS,UCN-5812EPF-1(PLCC)	IC-732
Y401	CRYSTAL, 4MHZ (SMT)	CR-36-4M

** Order present firmware revision.

Table 4-3
Model 2000 motherboard, parts list

Circuit desig.	Description	Keithley part no.
	CONTACT, FUSE	2001-314B
	CRIMP CONTACT ROUND	CS-760
	HEAT SINK FOR U124	HS-41
	SOCKET PLCC-032-T-A FOR U156,157	SO-143-32
	SPRING, COMPRESSION	SP-5
	4-40X5/16 PHILLIPS PAN HD FOR IEEE CS TO BD	4-40X5/16PPH
AT101	IC,DUAL HIGH CMR/SPEED OPTO,HCPL-2631	IC-588
C101,160,163,174,180,186,207	CAP, .1UF, 10%, 25V, CERAMIC (0805)	C-495-.1
C102	CAP,.01UF,10%,1000V,CERAMIC	C-64-.01
C104	CAP,100UF,20%,63V,ALUM ELEC	C-403-100
C105	CAP, .22UF, 20%, 400V FILM	C-513-.22
C106	CAP, 15P, 1%, 100V CERAMIC (0805)	C-512-15P
C107	CAP,.1UF, 20%,50V,CERAMIC(1206)	C-418-.1
C109	CAP, 2.2UF, 20%, 63V, POLYCARB	C-480-2.2
C112,248	CAP, .01, 5%, 50V, NPO(1812)	C-514-.01
C113,114,119,126,246,247	CAP, 1000P, 10%, 100V, CERAMIC (1206)	C-451-1000P
C115	CAP, .33UF, 20%, 63V, POLYCARBONATE	C-482-.33
C117,147,151,191,234,237	CAP,.1UF, 20%,50V,CERAMIC(1206)	C-418-.1
C120	CAP, 270PF, 5%, 100V, CERAMIC (0805)	C-465-270P
C121,132,134,140	CAP, 220PF, 10%, 100V, CERAMIC (1206)	C-451-220P
C123,245	CAP, 1000P, 10%, 100V, CERAMIC (1206)	C-451-1000P
C131,148	CAP, 1000UF, 20%, 50V ALUM ELEC	C-469-1000
C135,203,198,183,187,197,249	CAP, .1UF, 10%, 25V, CERAMIC (0805)	C-495-.1
C137	CAP, 33PF, 5%, 100V, CERAMIC (0805)	C-465-33P
C145	CAP, 1000pF, 20%, 50V, CERAMIC (1206)	C-418-1000P
C146	CAP, 2200UF, 20%, 16V ALUM ELEC	C-473-2200
C153,111,225,122,118,155,116	CAP, .1UF, 10%, 25V, CERAMIC (0805)	C-495-.1
C156	CAP, 6800UF, -20+100%, 16V ALUMINUM	C-313-6800
C157,179	CAP,100PF, 5%, 100V, CERAMIC(0805)	C-465-100P
C171,177	CAP, 2200P, 10%, 100V CERAMIC	C-430-2200P
C175	CAP, 10UF,20%, 25V, TANTALUM (D7243)	C-440-10
C178,167,172,169,161,103,128	CAP, .1UF, 10%, 25V, CERAMIC (0805)	C-495-.1
C194,182,199,200,136,233,232	CAP, .1UF, 10%, 25V, CERAMIC (0805)	C-495-.1
C204-206,190,173,139,138,162	CAP, .1UF, 10%, 25V, CERAMIC (0805)	C-495-.1
C209	CAP, 22UF, 20%, 25V, TANTALUM (D7243)	C-440-22
C213,212,133,124,159,154,230	CAP, .1UF, 10%, 25V, CERAMIC (0805)	C-495-.1
C221,168,185	CAP, .1UF, 10%, 25V, CERAMIC (0805)	C-495-.1
C222	CAP, 47P, 5%, 100V, CERAMIC (0805)	C-465-47P
C224,141,158,150,176,219,220	CAP, 47P, 5%, 100V, CERAMIC (0805)	C-465-47P

Table 4-3(cont.)
Model 2000 motherboard, parts list

Circuit desig.	Description	Keithley part no.
C241	CAP, .01UF, 10%, 50V CERAMIC(0805)	C-491-.01
C242,243	CAP, .01UF, 10%, 50V CERAMIC(0805)	C-491-.01
C244	CAP, 1000pF, 20%, 50V, CERAMIC (1206)	C-418-1000P
CR102,103	DIODE,BRIDGE,VM18	RF-52
CR104	DIODE,SILICON,W04M (CASE WM)	RF-46
CR105,108,114	DIODE, SWITCHING, MMBD914 (SOT-23)	RF-83
CR106	DIODE, BRIDGE PE05 (CASE KBU)	RF-48
CR110,CR118	DIODE, DUAL HSM-2822T31(S0T-23)	RF-95
CR111,112,115-117	DIODE, DUAL SWITCHING, BAV99L(SOT-23)	RF-82
E101,102	SURGE ARRESTOR, CG3-1.5L	SA-4
J1006	CONN, MICRODIN W/GND FINGERS	CS-792
J1007	CONN, RT ANGLE, MALE, 9 PIN	CS-761-9
J1008	CONN,RIGHT ANGLE,24 PIN	CS-501
J1014	CONN, HEADER STRAIGHT SOLDER PIN	CS-368-16
J1015	CONNECTOR, HEADER	CS-784-4
J1016	CONN, MALE, 5-PIN (MOLEX 42491)	CS-784-5
J1017	CONNECTOR, HEADER STRAIGHT SOLDER PIN	CS-368-14
K102,101	RELAY, MINATURE (DPDT) TQ2E-L2-5V	RL-155
K103	RELAY, MINI SIGNAL REL	RL-163
L101,103,102,104	FERRITE CHIP 600 OHM BLM32A07(1206)	CH-62
L105,L106	FERRITE CHIP 600 OHM BLM32A07(1206)	CH-62
L107,108	CHOKE	CH-61
L109	CHOKE	CH-63-22
LS101	BEEPER, 5V, 30MA, BRT1209P-06-C	EM-5
Q101,102	TRANS, C-CHAN MOSFET, 2SK1412(TO-220ML)	TG-276
Q103,110,112,115,118,128,130	TRANS, NPN, MMBT3904 (SOT-23)	TG-238
Q104-109,113,114,117,120-126	TRANS, N CHANNEL JFET, SNJ132199(SOT-23)	TG-294
Q119	TRANS,P CHANNEL JFET,J270 (TO-92)	TG-166
Q116,111,129	TRANS, PNP, MMBT3906L(SOT-23)	TG-244
Q127,131,132,133	TRANS, N-MOSFET, VN0605T (SOT-23)	TG-243
R101,102	RES, 1M, 5%, 125MW, METAL FILM (1206)	R-375-1M
R103,107,108,113,120,121,124	RES, 24K, 5%, 1W, 200V, THICK FILM 251	R-437-24K
R104,105	RES,549K, .1%,1/4W METAL FILM	R-315-549K
R106	RES,11K,.1%,1/10W,METAL FILM	R-263-11K

Table 4-3(cont.)
Model 2000 motherboard, parts list

Circuit desig.	Description	Keithley part no.
R109	RES, 1K, 1%, 125mW, METAL FILM (1206)	R-391-1K
R110,133	RES NET, 9K-1K, MICRO DIVIDER	TF-246-2
R114	RES, 604, 1%, 100MW THICK FILM(0805)	R-418-604
R115	RES, 5K, .1%, WIREWOUND	R-249-5K
R117	RES NET, 100K, 9.9M, METAL FILM	TF-224
R122,134,272,181	RES, 1K, 1%, 125mW, METAL FILM (1206)	R-391-1K
R123	RES, 73.2K, 1%, 100MW, THICK FILM(0805)	R-418-73.2K
R127	RES, 33.2K, 1%, 100MW, THICK FILM (0805)	R-418-33.2K
R129	RES, 215, 1%, 100MW, THICK FILM (0805)	R-418-215
R135	RES, 33.2K, 1%, 100MW, THICK FILM (0805)	R-418-33.2K
R139,148,163	RES, 24K, 5%, 1W, 200V, THICK FILM 2512	R-437-24K
R142	RES,10,5%,125MW,METAL FILM(1206)	R-375-10
R145,156,321,322	RES, 100, 1%, 100MW, THICK FILM (0805)	R-418-100
R146	RES, 1.1M, 5%, 125MW, METAL FILM (1206)	R-375-1.1M
R147	RES, 732K,1%, 100MW, THICK FILM(0805)	R-418-732K
R149,151	RES, 150, 1%, 100MW, THICK FILM(0805)	R-418-150
R150	RES, 25.5K, 1%, 100MW, THICK FILM (0805)	R-418-25.5K
R152,143,137	RES,49.9K,1%,125MW, METAL FILM (1206)	R-391-49.9K
R153	RES NET, 3.6K MICRO DIVIDER	TF-246-1
R154,230	RES, 49.9K, 1%, 100MW THICK FILM(0805)	R-418-49.9K
R155	RES, 4.99K, 1%, 100MW THICK FILM(0805)	R-418-4.99K
R157	RES, 511, 1%, 100MW, THICK FILM (0805)	R-418-511
R158	RES, .1, 1%, 2W, 4-TERMINAL MOLDED	R-342-.1
R159,166,185,275,307,314	RES, 475, 1%, 125mW, METAL FILM (1206)	R-391-475
R164,112	RES, 100K, 1%, 125mW, METAL FILM (1206)	R-391-100K
R168	RES, 270,5%, 250mW, METAL FILM (1210)	R-376-270
R169,214,218	RES, 4.99K, 1%, 100MW THICK FILM(0805)	R-418-4.99K
R172,167,160	RES, 1M, 1%, 100MW, THICK FILM(0805)	R-418-1M
R176,179,183,186,193,130,177	RES, 100K, 1%, 100MW THICK FILM(0805)	R-418-100K
R178,184,187,161,213,257,248	RES, 100, 1%, 100MW, THICK FILM (0805)	R-418-100
R188	RES, 49.9, 1%, 125mW, METAL FILM (1206)	R-391-49.9
R189	RES, 3.01K, 1%, 125MW, METAL FILM(1206)	R-391-3.01K
R192	RES, 6.98K, 1%, 125MW, METAL FILM(1206)	R-391-6.98K
R194	RESISTOR, METAL FILM	R-443-7.06K
R195	RESISTOR, METAL FILM	R-443-70.6K
R196	RES, 2.21K, 1%, 100MW, THICK FILM (0805)	R-418-2.21K
R200,190,165,182,111,284,296	RES, 1K, 1%, 100MW, THICK FILM (0805)	R-418-1K
R201,204,223,229,231,233,206	RES, 4.75K, 1%, 100MW, THICK FILM (0805)	R-418-4.75K
R202,263,249,224,319	RES, 10K, 1%, 100MW, THICK FILM (0805)	R-418-10K
R205	RES, 10, .5%, 1/8W, METAL FILM	R-246-10
R215	RES, 4.42K, 1%, 125MW METAL FILM(1206)	R-391-4.42K
R216	RES, 2.21K, 1%, 125mW, METAL FILM (1206)	R-391-2.21K

Table 4-3(cont.)
Model 2000 motherboard, parts list

Circuit desig.	Description	Keithley part no.
R220,221,264,212,217	RES, 2.21K, 1%, 100MW, THICK FILM (0805)	R-418-2.21K
R225	RES, 470,5%, 125MW, METAL FILM(1206)	R-375-470
R226,228,235,237,250,252,255	RES, 475, 1%, 100MW, THICK FILM (0805)	R-418-475
R234	RES, 5.11K, 1%, 100MW, THICK FILM (0805)	R-418-5.11K
R238,244,254,293	RES, 4.75K, 1%, 100MW, THICK FILM (0805)	R-418-4.75K
R241	RES, 34K, 1%, 100MW, THICK FILM (0805)	R-418-34K
R243,259	RES, 10, 10%, 100MW, THICK FILM(0805)	R-418-10
R245	RES, 475, 1%, 100MW, THICK FILM (0805)	R-418-475
R246	RES, 82.5, 1%, 100MW, THICK FILM (0805)	R-418-82.5
R261	RES, 200, 1%, 100MW, THICK FILM (0805)	R-418-200
R267,270	RES, .0499, 1%, 100MW, THICK FILM(0805)	R-418-.0499
R271	RES NET (SOIC)	TF-245
R273,274	RES, 475, 1%, 125mW, METAL FILM (1206)	R-391-475
R277	RES, 66.5K, 1%, 100MW, THICK FILM(0805)	R-418-66.5K
R279,140,256,299	RES, 1K, 1%, 100MW, THICK FILM (0805)	R-418-1K
R280,294	RES, 49.9, 1%, 100MW THICK FILM(0805)	R-418-49.9
R283	RES, 470,5%, 125MW, METAL FILM(1206)	R-375-470
R287	RES, 1.28M, .1%, 1/8W METAL FILM	R-176-1.28M
R288,289,290	RES, 1K, 1%, 100MW, THICK FILM (0805)	R-418-1K
R291,292	RES, 47.5K, 1%, 100MW THICK FILM (0805)	R-418-47.5K
R295,118,175,276,282,316	RES, 10K, 1%, 100MW, THICK FILM (0805)	R-418-10K
R297,278,281	RES, 357, 1%, 100MW, THICK FILM (0805)	R-418-357
R300	RES, 2.15K, 1%, 125MW THIN FILM (1206)	R-423-2.15K
R302,303	RES, 499, 1%, 100MW THICK FILM(0805)	R-418-499
R304	RES, 20K, 1%, 100MW THICK FILM (0805)	R-418-20K
R309	RES,1K,.1%,1/10W,METAL FILM	R-263-1K
R310	RES, 9.09K, .1%, 1/10W, METAL FILM	R-263-9.09K
R311	RES, 392, 1%, 100MW, THICK FILM (0805)	R-418-392
R312,313	RES, 332K,1%, 100MW, THICK FILM (0805)	R-418-332K
R315	RES, 100K, 1%, 100MW THICK FILM(0805)	R-418-100K
R317,320	RES, 10, 10%, 100MW, THICK FILM(0805)	R-418-10
R318	RES, 73.2K, 1%, 100MW, THICK FILM(0805)	R-418-73.2K
R324	RES, 2K, 1%, 125mW, METAL FILM (1206)	R-391-2K
S101	SWITCH, PUSHBUTTON, 8 POLE	SW-468
TP102,103,104,105,106	CONN,TEST POINT	CS-553
U101	INTEGRATED CIRCUIT	IC-846
U102,118	IC, J-FET, OP-AMP, TLE2081CD(SOIC)	IC-967
U103,105,111,129	IC,CMOS ANALOG SWITCH DG211DY(SOIC)	IC-768
U104	IC, MOSFET DRIVER, TLP591B	OC-877

Table 4-3(cont.)
Model 2000 motherboard, parts list

Circuit desig.	Description	Keithley part no.
U106,109,121,130,134	IC, 8 STAGE SHIFT/STORE,MC14094BD(SOIC)	IC-772
U107,108	IC, PHOTO, DARLINGTON TRANS, PS2506L-1	IC-911
U110	IC,TRMS TO DC CONVERTER, 637JR (SOLIC)	IC-796
U112	IC, J-FET OP-AMP LF357M(SOIC)	IC-966
U113	IC, OP-AMP, LTC1050CS8(SOIC)	IC-791
U114	ICM DUAL J-FET OP-AMP, OP-282GS,(SOIC)	IC-968
U116	IC, DARLINGTON ARRAY, ULN2003L (SOIC)	IC-969
U117,145	IC, VOLT. COMPARATOR,LM311M (SOIC)	IC-776
U119	IC,NEG VOLTAGE REG -15V,500MA,79M15	IC-195
U120,131,115	IC, QUAD COMPARATOR,LM339D (SOIC)	IC-774
U123	IC, DUAL PICOAMP OP-AMP AD706JR (SOIC)	IC-910
U124	IC,+5V REGULATOR,500mA,7805	IC-93
U125	IC,POS VOLTAGE REG +15V,500MA,7815	IC-194
U126	IC, OP-AMP, AD705JR(SOIC)	IC-814
U133	IC, CMOS ANAL SWITCH, DG444DY, (SOIC)	IC-866
U135	IC, 16BIT MICROPROCESSOR MC68306FC16	LSI-154
U136	IC, SERIAL EPROM 24LC16B(SOIC)	LSI-153
U137,166	IC, HI-SPEED BIFET OP-AMP, AD711JR(SOIC)	IC-894
U138,132	INTEGRATED CIRCUIT, OPA177GS(SOIC)	IC-960
U139	IC, DUAL BIPOLAR OP-AMP, LT1124C58	IC-955
U141	IC, PRECISION REFERENCE, LM399	196-600A
U142	IC, OP-AMP, NE5534D (SOIC)	IC-802
U144	IC, LOW DROPOUT REGULATOR, LM295T	IC-962
U146	IC,POS NAND GATES/INVERT,74HCT14(SOIC)	IC-656
U147,164	IC, DUAL D-TYPE F/F, 74HC74(SOIC)	IC-773
U148,153	IC, QUAD 2 IN NOR, 74HCT02 (SOIC)	IC-809
U149	IC, NCHAN LAT DMOS QUADFET,SD5400CY SOIC	IC-893
U150	IC,OPTOCOUPLER,2611	IC-690
U151,152	IC,32KX8 STAT CMOS RAM,D43256C(SOMETRIC)	LSI-93-100
U154	IC, QUAD D FLIP FLOP W/CLK,RESET 74HC175	IC-923
U155	IC,OPTOCOUPLER,2601	IC-239
U156	PROGRAM	2000-804-**
U157	PROGRAM	2000-803-**
U158	IC, GPIB ADAPTER, 9914A (PLCC)	LSI-123
U159	IC +5V RS-232 TRANSCEIVER, MAX202(SOIC)	IC-952
U160	IC,OCTAL INTER BUS TRANS,75161(SOLIC)	IC-647
U161	IC,OCTAL INTERFACE BUS,75160(SOLIC)	IC-646
U162	PROGRAM	2000-802-**
U163	IC, 8-CHAN ANA MULTIPLEXER,DG408DY(SOIC)	IC-844

Table 4-3(cont.)
Model 2000 motherboard, parts list

Circuit desig.	Description	Keithley part no.
VR101,114	VAR, 576V METAL OXIDE	VR-5
VR102	DIODE, ZENER 6.2V, BZX84B6V2 (SOT-23)	DZ-87
VR103,104	DIODE, ZENER, 6.8V,MMSZ5235BT1 (SOD-23)	DZ-100
VR105,106,115,116	DIODE, ZENER 11V,MMSZ11T1 (SOD-123)	DZ-103
VR107,108	DIODE, ZENER 3.3V, MMBZ5226BL(SOT-23)	DZ-94
VR109	DIODE, ZENER 17V, MMBZ5247BL (SOT-23)	DZ-104
VR110	DIODE,ZENER 5.1V, BZX84C5V1 (SOT-23)	DZ-88
VR112,113	DIODE, ZENER, 6.2V MMS26V2 SOD-123	DZ-97
Y101	CRYSTAL, 14.7456MHZ	CR-39
Y102	OSCILLATOR HIGH SPEED CMOS 12MHZ	CR-37

** Order present firmware revision.

Table 4-4
Model 2000 mechanical, parts list

Description	Keithley part no.
2-56X5/8 PHILLIPS PAN HEAD SCREW SCANNER BOARD ASSEMBLY	2-56X5/8PPH
4-40X1/4 PHIL FLAT HD UNDERCUT SR WRAP TO CHASSIS	4-40X1/4PFHUC
4-40X5/16 PHILLIPS PAN HD SEMS MOTHER BOARD TO CHASSIS	4-40X5/16PPHSEM
6-32 KEP NUT SAFETY GROUND	6-32KEPNUT
6-32X1 PH PAN HD SEMS SCR FOR MOTHER BOARD SHIELD	6-32X1PPHSEM
6-32X1/4 PHIL. PAN HD SEMS CARD GUIDE TO CHASSIS	6-32X1/4PPHSEM
6-32X1/4 PHILLIPS FLAT HD FOR REAR FOOT	6-32X1/4PFH
8-32 SMALL NUT FOR TRANSFORMER MOUNTING	8-32SMNUT
#8 INTERNAL TOOTH LOCKWASHER FOR TRANSFORMER MOUNTING	8LKWA

Table 4-4(cont.)
Model 2000 mechanical, parts list

Description	Keithley part no.
BANANA JACK, PUSH-IN, BLACK	BJ-13-0
BANANA JACK, PUSH-IN, RED	BJ-13-2
BEZEL, REAR	428-303D
BRACKET, REAR PANEL SCANNER COVER PLATE	2001-328C
CABLE CLAMP FOR DISPLAY CABLE & TR-299 WIRE	CC-37
CABLE CLAMP TIE WRAP, NYLON, 4" LONG FOR FRONT/REAR WIRES	CC-38-2
CAPTIVE PANEL SCREW FOR BEZEL	FA-232-1C
CARD GUIDE/SHIELD	2000-311A
CHASSIS ASSEMBLY	2000-309D
CONNECTOR, HARDWARE KIT FOR IEEE	CS-713
COVER	2000-307C
DISPLAY LENS	2000-304A
FASTENER FOR EARS	FA-230-2B
FOOT	428-319A
FOOT, EXTRUDED	FE-22A
FOOT,RUBBER	FE-6
FRONT PANEL OVERLAY	2000-303A
FRONT PANEL PRINTED	2000-318B
FRONT/REAR SWITCH ROD	2001-322A
FUSE HOLDER FOR PM-1-1	FH-35-1
FUSE, 3A, 250 FOR CURRENT INPUT JACK	FU-99-1
FUSE 0.25A FOR FH-35-1	FU-96-4
JACK, CURRENT INPUT	2001-312D
LINE MODULE	PM-1-1B
LUG	LU-130
LUG	LU-88
MOTHERBOARD SHIELD	2000-306B
MOUNTING EAR, LEFT	428-338B
MOUNTING EAR, RIGHT	428-328E
PC BOARD STOP	2001-371A
PLASTIC PLUG FOR SCANNER COVER PLATE	FA-240
POWER ROD	2001-320A
SCREWLOCK, FEMALE FOR RS-232	CS-725
SWITCHPAD	2000-310A
TRANSFORMER	TR-299B

Table 4-5
Model 2000 miscellaneous, parts list

Description	Keithley part no.
CALIBRATION MANUAL PACKAGE	2000-905-00
COVER PANEL, SCANNER	2001-372A
DISK PROGRAMMING	2000-DSK-81
HANDLE	428-329F
LINE CORD	CO-7
QUICK REFERENCE GUIDE PACKAGE	2000-903-00
TEST LEADS	CA-22
USER'S MANUAL PACKAGE	2000-900-00

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Service Form

Model No. _____ **SeriaNo.** _____ **Date**_____

Name and Telephone No. _____

Company _____

List all control settings, describe problem and check boxes that apply to problem. _____

_____

_____

❑ Intermittent ❑ Analog output follows display ❑ Particular range or function bad; specify

_____

❑ IEEE failure ❑ Obvious problem on power-up ❑ Batteries and fuses are OK

❑ Front panel operational ❑ All ranges or functions are bad ❑ Checked all cables

Display or output (check one)

❑ Drifts ❑ Unable to zero ❑ Unstable

❑ Overload ❑ Will not read applied input

❑ Calibration only ❑ Certificate of calibration required ❑ Data required

(attach any additional sheets as necessary)

Show a block diagram of your measurement including all instruments connected (whether power is turned on or not). Also, describe signal source.

Where is the measurement being performed? (factory, controlled laboratory, out-of-doors, etc.)_____

_____

What power line voltage is used?_____ Ambient temperature?_____°F

Relative humidity? _____Other?_____

Any additional information. (If special modifications have been made by the user, please describe.)

_____

_____

Be sure to include your name and phone number on this service form.

KEITHLEY

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Cleveland, Ohio 44139

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